AFFDL-TR-72-64 VOLUME II

OF BONDED AND BOLTED JOINTS IN ADVANCED FILAMENTARY COMPOSITE MATERIALS VOLUME II, FABRICATION, INSPECTION AND TESTING

A. C. Fehrle, G. J. Gilbert, E. C. Young, et al LOCKHEED-GEORGIA COMPANY MARIETTA, GEORGIA

TECHNICAL REPORT AFFDL-TR-72-64 , VOLUME II June 1972

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Security Classification

DOCUMENT CONTROL DATA - R & D				
	annotation must be entered when the overall report is classified)			
originating activity (Corporate author) Lockheed-Georgia Company	28. REPORT SECURITY CLASSIFICATION			
	Unclassified			
A Division of Lockheed Aircraft Corporation	26 GROUP			
Marietta, Georgia 30060				
DEVELOPMENT OF AN UNDERSTANDING OF	THE FATIGUE PHENOMENA OF RONDED			
AND BOLTED JOINTS IN ADVANCED FILAME				
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4 DESCRIPTIVE NOTES (Type of report and inclusive dates)				
Final Technical Report August 1970 th	nrough April 1972			
5 AUTHOR(S) (First name, middle initial, last name)				
Albert C. Fehrle, Gerald J. Gilbert, and Edwa	ard C. Vouna at al			
Albert C. Teilite, Celaid 3. Offbert, and Edward	ad C. Toung, et al			
6. REPORT DATE				
June 1972	78. TOTAL NO. OF PAGES 76. NO OF REFS			
BA. CONTRACT OR GRANT NO				
	98. ORIGINATOR'S REPORT NUMBER(S)			
F33615-70-C-1302	AFFDL-TR-72-64 -Vol II			
4364				
c.	9h. OTHER REPORT NO(5) (Any other numbers that may be assigned			
	this report)			
d.	ER-11319			
10 DISTRIBUTION STATEMENT				
A LO LIO L LO	t			
Approved for public release; distribution unlimited.				
1: SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY			
Volume II, Fabrication, Inspection and Testing	Air Force Flight Dynamics Laboratory			
	Air Force Systems Command			
	Wright-Patterson AFB, Ohio			
13 ABSTRACT				

This is Volume II of a final report presented in three volumes; Vol I - Analysis Methods; Vol II - Fabrication, Inspection and Testing; Volume III - Fatigue Analysis and Failure Mode Studies. Fabrication and inspection methods were established which resulted in specimens of uniform high quality fabricated to close tolerances. Both bonded and bolted joints of widths from one to ten inches were evaluated. Primary emphasis was on joints in boron-epoxy, and between boron-epoxy and titanium or aluminum; ho rever limited evaluations of graphite-epoxy/titanium and fiberglass-epoxy/titanium were included.

Joint configuration evaluated were: single and double splice butt joints; boron-epoxy to metal stepped single scarf joints; and surface to understructure attachments.

All laminates and specimens were inspected non-destructively. Base material properties and process control measures were verified by destructive testing. Developing testing techniques and actual specimen testing was a major portion of the program.

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bonded joints							
mechanical joints							
boron-epoxy							
composite materials							
Graphite-epoxy composite materials							
fiberglass-epoxy composite materials							
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OF BONDED AND BOLTED JOINTS IN ADVANCED FILAMENTARY COMPOSITE MATERIALS VOLUME II, FABRICATION, INSPECTION, AND TESTING

A. C. Fehrle, G. J. Gilbert, E. C. Young, et al LOCKHEED-GEORGIA COMPANY MARIETTA, GEORGIA

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FOREWORD

This report summarizes the work accomplished under Contract F33615-70-C-1302, "Development of an Understanding of the Fatigue Phenomena of Bonded and Bolted Joints in Advanced Filamentary Composite Materials", Project Number 4364, and was prepared by the Lockheed-Georgia Company, a Division of Lockheed Aircraft Corporation. The work reported herein was sponsored by the Advanced Composite Branch, Air Force Flight Dynamics Laboratory, Air Force Systems Command, Wright-Patterson Air Force Buse, Ohio 45433. Mr. Rodman Joblove, FBC, was the Air Force Project Engineer and Mr. A. C. Fehrle vas the Lockheed-Georgia Program Manager.

The authors of Volume II are Dr. E. C. Young, Mr. A. R. Holland, Mr. W. P. Lanier, Mr. G. J. Gilbert, and Mr. A. C. Fehrle. Dr. E. C. Young was responsible for the fabrication of all specimens including laminate coupons, bonded joints and mechanical joints. Mr. A. R. Holland was responsible for basic material evaluation and Mr. W. P. Lanier was responsible for the non-destructive inspections of all test specimens. Mr. G. J. Gilbert and Mr. A. C. Fehrle were responsible for specimen testing and basic data evaluation.

This technical report has been reviewed and is approved.

For internal control purposes, this report has been assigned Lockheed-Georgia Company Report Number ER-11319.

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ABSTRACT

Fabrication and inspection methods were established which resulted in specimens of uniform high quality fabricated to close tolerances. Both bonded and bolted joints of widths from one to ten inches were evaluated. Primary emphasis was on joints in boron-epoxy, and between boron-epoxy and titanium or aluminum. However, limited evaluations of graphite-epoxy/titanium and fiberglass-epoxy/titanium were included. Joint configurations evaluated were single and double splice butt joints; boron-epoxy to metal stepped single scarf joints; and surface to understructure attachments. All laminates and specimens were inspected non-destructively. Base material properties and process control measures were verified by destructive testing. Developing testing techniques and actual specimen testing was a major portion of the program.

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SECTION I

This program was undertaken to develop an understanding of the fatigue phenomena of structural joints in advanced filamentary composite materials and to develop analytical and testing methods to support proper fatigue design of advanced composite structural joints. The program included the evaluation of both bonded and bolted joints. Primary emphasis was placed on joints in boron-epoxy; however, a limited evaluation of bonded joints in graphite-epoxy and glass-epoxy were included. Although the sizes of the joints for this investigation were small (one to ten inches in width), all configurations evaluated are representative of typical structural joints currently utilized in advanced filamentary composite structures.

The program consisted of three major areas of investigation:

- o Analysis Methods
- Fabrication, Inspection and Testing
- o Fatigue Analysis and Failure Mode Studies

Analytical methods for determining joint stresses were divided into two major tasks, (1) analysis of bonded joints and (2) analysis of bolted joints. Primary emphasis was placed on the development of a closed form elastic analysis procedure for bonded joints. This analysis was used to evaluate a number of joint variables. A "plastic zone" approach was used to extend the closed form analysis procedure to include joints with inelastic adhesive stress-strain behavior. The results of the elastic closed form solution were verified with finite element analyses, photoelastic analysis and strain gage data. Finite element analyses were used to evaluate the step lap bonded joints and bolted joints.

ostrierienten trentrierienten anternationen anternationen anternationen trentrierienten anternationen The experimental program consisted of fabrication, inspection and testing of a large quantity of joint specimens. Fabrication and inspection methods were established which resulted in specimens being fabricated to close tolerances and of uniform high quality. This provided specimens that would consistently develop stresses that were predicted by the analytical methods. Developing testing techniques and actual specimen testing was a major portion of the program. Establishing proper specimen support was essential to

obtaining repeatable joint strengths within a specimen configuration. Equally important was determining the proper cyclic rate for the different stress ratios and specimen configurations to preclude specimen heating and erratic fatigue lives.

Evaluation of the experimental results was divided into two separate but related tasks. These tasks were failure mode studies and fatigue analyses. The failure mode studies mentioned were photomicrographic analyses of the failure surfaces. This failure mode analysis does not replace but augments the gross failure modes generally defined within the experimental phases of a program. The photomicrographic analysis conducted within this program established failure modes related to specific joint unsigns, joint loading and fatigue history. The fatigue analysis established relationships between specimen configuration, joint variables, material combinations, loading conditions and stress ratio effects for constant amplitude loading. The relationship between constant amplitude fatigue and spectrum fatigue (block and realistic) was also evaluated for specific joint configurations.

This report is divided into three separate volumes each containing the developments accomplished within a major area of investigation. Each volume is a self-contained document, complementing the other two volumes but not dependent upon them for coherence or continuity. The titles of the three volumes are:

Volume I - Analysis Methods

Volume 11 - Fabrication, Inspection and Testing

Volume III - Fatigue Analysis and Failure Mode Studies

Volume II is divided into three sections: Fabrication, Technical Inspection and Quality Assurance, and Test Program. The Fabrication section contains details related to laminate fabrication using boron-epoxy, graphite-epoxy, and fiberglass-epoxy. Methods for joining the various bonded and mechanical joints is also discussed in detail. The Technical and Quality Assurance section contain information elated to nondestructive in the fitting of the base materials, and process control requirements for all specimens fabricated. The Test Program section identifies all test, instrumentation, and programming equipment used during the entire

program. Also discussed are the general and specific test requirements for the different joint configurations. Test procedures and test results are included for all specimen configurations and program phases.

Included in the Appendices of this Volume are the Fabrication and Inspection Logs, Test Data Forms, and Joint Designs.

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SECTION II

2.1 GENERAL

2.1.1 Introduction to Specimen Configurations

This section describes in summary fashion the types of specimens that were fabricated and provides an overview of the fabrication program. Location of precisely detailed specifications and data for individual specimens as cited in Sections 2.1.2, 2.1.3, and 2.1.4. Details of fabrication procedures are presented in Section 2.2 through Section 2.8. Specimens fabricated for this program are illustrated in Figures 1 through 6 and are listed below:

Configuration "A": Single Splice Butt Joint - Bonded

Configuration "B": Boron to Metal Stepped Single Scarf Joint

Configuration "C": Surface to Understructure Attachment (Titanium tee) -

Bonded

Configuration "D": Double Splice Butt Joint - Bonded

Configuration "E": Single Splice Butt Joint - Bolted

Configuration "F": Surface to Understructure Attachment (aluminum tee) -

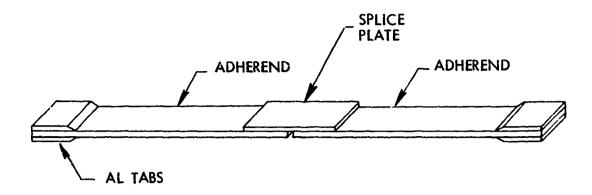
Mechanical

All Phase I specimens were I" wide as illustrated in Figures I through 6. These I" wide specimens constituted the major portion of the program. Intermediate width specimens (2" or 3" wide) were investigated in Phase II, and large scale joints were investigated in Phase III, as indicated below:

TABLE ! - SPECIMEN WIDTHS

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Configuration	Phase 1	Phase 11	Phase III
" A "	1"	3"	10"
"B"	1"	3"	10"
"C"	1"		
"D"	1"		
"E"	1"	2"	
"F"	1 "		



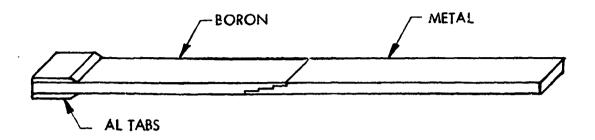
Size: Approx. 18" X i" width (Phase I, illustrated)

ADHEREND/SPLICE PLATE/ADHEREND

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Boron/Titanium/Boron
Boron/Boron/Boron
Boron/Aluminum/Boron
Graphite/Titanium/Graphite
Glass/Titanium/Glass

FIGURE 1 - CONFIGURATION "A" SINGLE SPLICE BUTT JOINT - BONDED

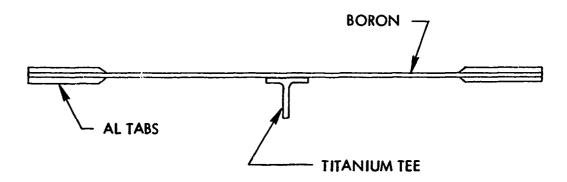


Size: Approx. 18" X 1" width (Phase I, illustrated)

ORON/METAL

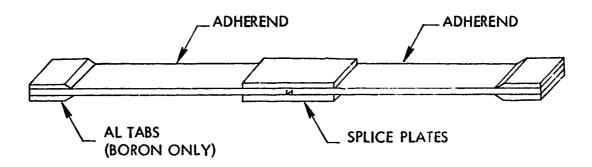
Boron/Titanium
Boron/Aluminum

FIGURE 2 - CONFIGURATION "B" BORON TO METAL STEPPED SINGLE SCARF JOINT



Size: 18" X 1"

FIGURE 3 - CONFIGURATION "C" SURFACE TO UNDERSTRUCTURE ATTACHMENT-BONDED



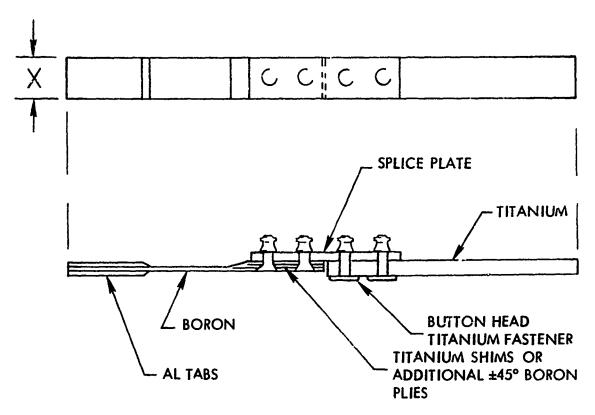
Size: Approx. 18" X 1"

ADHEREND/SPLICE PLATES/ADHEREND

Boron/Titanium/Boron
Titanium/Boron/Titanium

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FIGURE 4 - CONFIGURATION "D" DOUBLE SPLICE BUTT JOINT - BONDED



Size: Approx. 18" X 1" width (Phase I, illustrated)

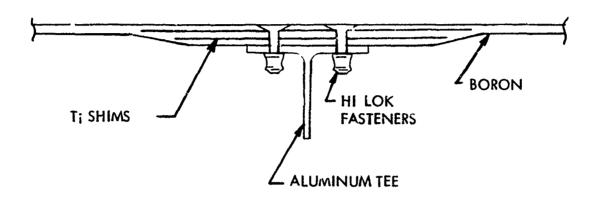
ADHEREND/SPLICE/ADHEREND

Boron + Ti shim buildup/Boron + Ti shim/Titanium

Boron + Ti shim buildup/Titanium/Titanium

Boron \pm 45° buildup/Titanium/Titanium

FIGURE 5 - CONFIGURATION "E" SINGLE SPLICE BUTT JOINT - BOLTED



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Size: 18" X 1" width

FIGURE 6 - CONFIGURATION "F" SURFACE TO UNDERSTRUCTURE ATTACHMENT - MECHANICAL

Approximately 75% of the specimens represented bonded joints; the remainder represented mechanical joints.

Material combinations across joints are listed in the appropriate figure. All bonded joints were bonded with Hysol EA 9601 adhesive previously designated Shell EPON 9601, except for some IA specimens which were used to evaluate a second adhesive, Narmco Metlbond 329. Where splice plates were used, the material of the splice plate is the second member of the triplet. For increased bearing strength, titanium shims (.012" thick Ti-6A1-4V annealed) or additional boron plies (±45° orientation) were interleaved between boron plies of the basic laminates in the mechanical joint specimens.

"Boron", as used in Figure 1 and elsewhere, refers to boron-epoxy laminate fabricated from Narmoo 5505 boron-epoxy prepreg 3" wide tape with glass fabric carrier. This prepreg contains nominal 0.004 inch diameter filaments collimated to 212 ± 4 filaments per inch. The matrix resin is a 350° F curing epoxy. Laminates cure to nominal 0.0054 inches per ply and contain approximately 50 volume percent boron filament in the cured condition. Ply orientations of $0^{\circ}/\pm 45^{\circ}$ or $0^{\circ}/90^{\circ}$ were used for bonded specimens. All bolted specimens used laminates of ply orientation $0^{\circ} \pm 45^{\circ}$, except for some unidirectional laminate specimens used for the Baseline Data Task.

The titanium alloy used throughout this program, including bearing reinforcement shims, was all Ti-6-Al-4V alloy with two exceptions. The extruded titanium tees for Configuration "C" was Ti-6Al-6V-2Sn alloy. The titanium splice plates and load plates of the Configuration "E" specimens was Ti-8Al-1Mo-1V alloy.

The aluminum splice plates (Configuration "A") and aluminum adherends (Configuration "B") were aluminum alloy 7075–T6. Extruded aluminum tees (Configuration "F") were also 7075 alloy.

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Fiberglass and graphite laminates were fabricated and used for Configuration "A" specimens in the Alternate Adherend Evaluation Task. The fiberglass laminate was fabricated using 3M 1002 S glass prepreg tape. The same ply orientation, $0^{\circ} \pm 45^{\circ}$, was used as for the baseline boron specimens.

Graphite laminates were fabricated using Fiberite Hy E 131 1B graphite/epoxy tape. Graphite laminates were also balanced 8-ply 0° ±45° orientations.

2.1.2 Citation of Detailed Specification Drawings

Detailed dimensions, tolerances, and references to materials and process standards are presented in the Drawings No. 7226-1302IA through 7226-1302IF which appear in Appendix C.

2.1.3 Citation of Program Test Plan and Specimen Identification Charts

Tables V through X of Section 4.1, TEST PROCEDURES – GENERAL, list the quantities of specimens fabricated and tested for each major Configuration ("A", "B", "C", etc.).

These tables also provide a breakdown of the specimen quantities per Phase (width) and Program Task (Baseline Data, Thickness Effects, etc.), as well as materials combinations (Adherend Combinations for bonded joints or Joint Elements for mechanically fastened joints) and variations in subconfigurations (ply orientations, titanium shims versus added boron plies, etc.).

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A guide to the specimen identification system is also presented in Section 4.1.

2.1.4 Citation of Fabrication and Inspection Logs

Fabrication and inspection details for all laminate panels and joint specimens are summarized in the log sheets of Appendix A.

2.1.5 Highlights of Lessons Learned in Fabrication

Fiberglass peel plies, Narmoo 1581/2054, were used to prepare the adhesive bonding surfaces on boron laminates panels for Configuration "A", "C", "D" bonded joint specimens. Early attempts to sand the bonding surfaces, in an attempt to obtain more uniform bondline thicknesses, caused wide variations in bond joint strength. The more reliable peel ply surface preparation resulted in bondline thicknesses generally in the range 0.004 to 0.006 inch.

A floating 0.020 inch Teflon gap spacer plate was used to control the gap at the butt joint in Configuration "A" specimens. See Figure 9, item 7.

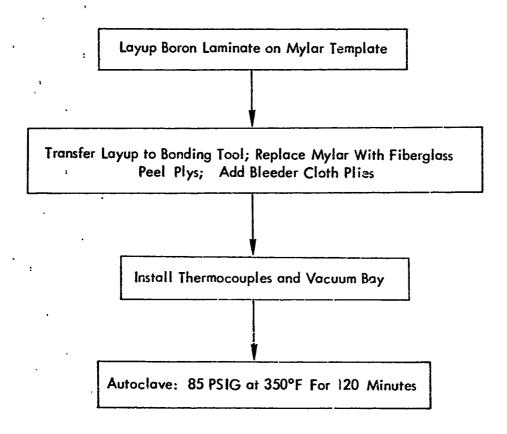
Chemical milling of the steps in the metallic adherends for the Configuration "B" scarf joint was required because of warpage encountered when mechanical milling was used.

Holes for fasteners were drilled in boron/boron assemblies using a diamond core drill. For boron/titanium assemblies an end mill was used for the titanium plate. Good back-up of boron laminates was required to prevent breakout on the back side of the hole. Holes in boron laminates were countersunk using a diamond tool.

Hi-Lok fasteners were wet installed and torqued to 30±1 inch-pounds. After 30 minutes fasteners were re-torqued to the same load to account for any relaxation due to squeeze-out of sealant from the faying surfaces.

2.2 BASIC LAMINATE PANEL FABRICATION

All panels from which material verification and acceptance specimens, basic program joint test specimens, and quality control coupons were constructed, were fabricated in essentially the same manner except for the Configuration B step-lap joint specimens. For these specimens, the laminate and joint fabrication was accomplished by the co-curing process.



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FIGURE 7 - STEP CHART FOR BASIC LAMINATE FABRICATION

The boron/epoxy laminates were fabricated using the following steps and procedures:

- 1. A template is prepared using 0.005" thick Mylar film. The panel dimensions are established by the number of specimens required from each panel. Panels are made slightly oversize to allow for panel trim and specimen machining. The largest panel fabricated was 36" X 56". Ninety-nine specimens one inch wide were cut from this panel.
- 2. The boron laminate is laid up using Narmco boron/5505 tape in accordance with the orientation and ply stacking for the given configuration. On the first ply, the scrim side of the tape is placed against the Mylar template. The final ply lay-up on the laminate is a layer of Narmco 104/2054 scrim.
 - a. The tape is visually inspected during lay-up to assure that the procedure has been carried out within the laminate specifications, i.e., 0.030" maximum gap, no overlapping of plies, no crossed filaments, etc.
 - b. Quality control specimens (used for determining the mechanical properties of the tape used in the lay-up) include a 15-ply, 3" X 6" flexu: all test coupon panel and a 6" X 9" cross-ply laminate (0°/±45° or 0°/90°) for tensile testing as an optional control specimen.

- The bonding tool is prepared by placing, on the tool surface, a sheet of Mylar the same size as the panel and covering it with Teflon-coated, 108 glass cloth.
- 4. The Mylar template is removed from the laminate and a fiberglass peel ply, Narmoo 1581/2054, is applied to each surface of the laminate. The laminate is placed on the tool surface over the Mylar and Teflon coated glass cloth.

NOTE: The application of the peel plies is omitted for panels which are not to be used for subsequent joint fabrication.

- 5. Dams are prepared by shearing aluminum strips 1" wide, and covering them with Teflon masking tape, these are then located adjacent to the laminate, and taped to the tool surface.
 - Dam thickness is calculated by multiplying the number of boron plies by 5.25 mils/ply, adding 0.008" for each peel ply, 0.003" for the Mylar, 0.003" for the Teflon coated glass, and 0.004" for each ply of 116 glass cloth used in the bleeder.
- 6. The resin bleeder system is placed over the laminate.
 - a. One ply of Teflon coated 108 glass cloth is trimmed net to the inside of the dam, and placed over the laminate.
 - b. The required layers of 116 glass cloth bleeder are trimmed to the inside of the dam and placed over the Teflon coated glass cloth. One ply of bleeder cloth is used for each 10 plies of laminate. The ply of bleeder is added for each two plies of peel ply prepreg used.
 - c. The bleeder system is covered with 0.003" Mylar (cut net to middle of the dam). This cover is taped to the top of the dam and slit on approximately 20" centers with 1/8" long slits as a minimum, one slit is made at each corner of the panel.

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- 7. The quality control specimens are located adjacent to the laminate on the tool, using the damming and bleeding procedure outlined in Steps 5 and 6, above.
- 8. Four thermocouples are on the installed tool adjacent to the dam and evenly spaced around the panel or panels.
- 9. The assembly is covered with two layers of 181 glass cloth. A chain is used to surround the assembly and provide air passage from the lay-up to the tool exhaust port. Extra 181 glass cloth is placed over the chain to

protect the bag during the curing cycle. The 181 glass cloth is then taped to the tool using high temperature masking tape.

- 10. High temperature, vacuum bag sealer compound tape is installed around the tool periphery outside the 181 glass cloth. Care is taken to be certain that no loose glass fibers are on or under the tape.
 - NOTE: The thermocouple wires are stripped of insulation, separated and placed on the sealer tape; additional sealer tape is placed over the wires and pressed to assure no leakage around the wires. Care is taken to be sure that the bared wires are not grounded against the tool surface.
- 11. The backing paper from the sealer compound tape is removed and the whole lay-up is covered with 0.002" nylon vacuum bag film for 375°F autoclave service.
- 12. Vacuum is applied to the tool vacuum port and the sealed bag is checked for leaks. The tool with the laminate assembly is installed in autoclave and rechecked for leaks.
- 13. Autoclave pressure is applied to 10 psig, and the vacuum is released. Autoclave pressure is held at 10 psig for 10 minutes to allow the bag to stabilize at atmospheric pressure, and is then increased to 85 psig.

14. The heating cycle was initially set at heat-up rate of 7°F/minute ±2°F/minute. However, the Narmco 5505 resin system appeared to be sensitive to heat-up rate in that the faster heat-up rates yielded more consistent and slightly higher laminate properties in terms of horizontal shear and transverse flexure. For this reason, the upper limit of 7°F to 9°F/minute has been used for the most recent laminates in this study. No noticeable change in laminate tensile or bond strengths were observed.

- 15. The autoclave cycle is maintained at 85 psig ±5 psig and 350°F ±10°F for 120 minutes.
- 16. After 120 minutes at curing temperature the part is allowed to cool to less than 150°F chile holding the pressure at 85 psig. The pressure is then released and the autoclave opened.
- 17. The part is removed from the autoclave, removed from the tool, and cleaned up. The peel ply is <u>not</u> removed from the boron panel until just prior to bonding tabs and splice plates.
- 18. The quality control specimens are prepared for testing. The 15 ply 0° laminate is cut into 0.50" X 4.0" specimens for longitudinal flexural testing, 3.0" x 0.50" for transverse flexural testing and 0.50" x 0.60" for horizontal shear. The 8-ply cross-ply laminate is fitted with 1.50" long fiberglass tabs of 0.080" thickness with the inboard ends beveled to 45° and tabs are bonded with FM123-2, 0.060 lb./ft. weight adhesive at 250°F and 20" vacuum. The 6" X 9" tabbed panel is then cut into 1" X 9" specimens using a diamond saw and specimens are ready for testing.

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2.3 JOINT FABRICATION - CONFIGURATION A, SINGLE SPLICE BUTT, BONDED

Laminates fabricated by the procedures outlined in Section 2.2 were used for the basic adherends in the fabrication of the Configuration A specimens. These specimens are illustrated in Figure 1, which is repeated below. Individual specimens were fabricated according to the requirements of Dwg. No. 7226-1301A, Appendix C.

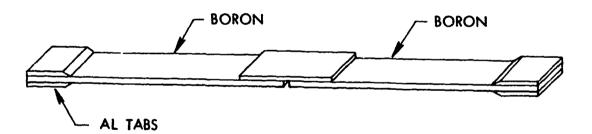


FIGURE ! (REPEATED) - CONFIGURATION "A" SINGLE SPLICE BUTT JOINT - BONDED

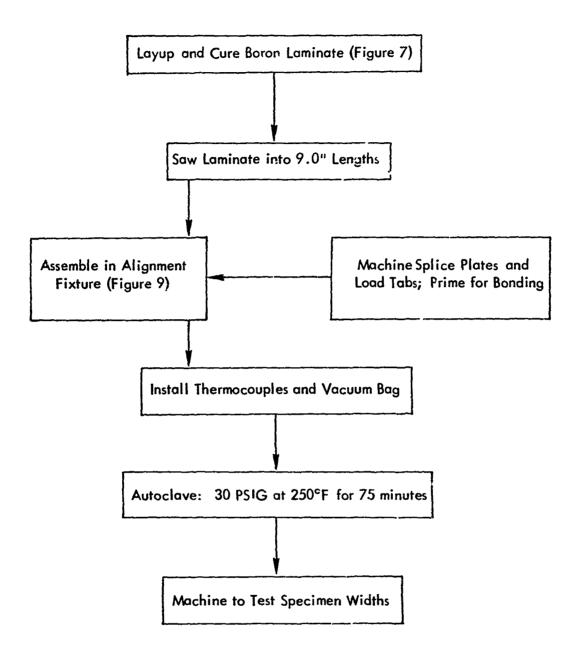


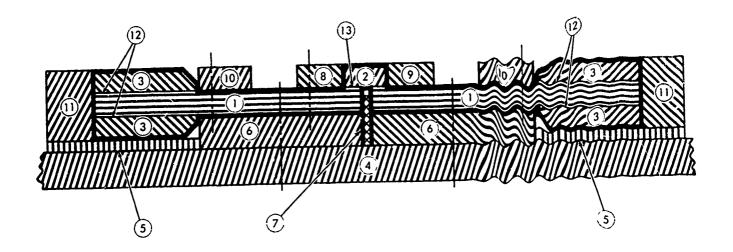
FIGURE 8 - STEP CHART FOR CONFIGURATION "A" SPECIMENS (ALSO FOR "D")

The following steps and procedures were taken to assure acceptable quality and uniformity of specimen fabrication:

- 1. The basic laminate is machined into 9.0" lengths (0° direction) using a diamond circular table saw normally employed for machining fiberglass panels in production. Panel widths varied from approximately 9" wide to 18" wide depending on the number of specimens to be obtained from each panel.
- 2. The splice plate material, either 6AL-4V annealed titanium or 7075-T6 aluminum, is machined to the thicknesses and configuration as specified on Dwg. No. 7226-1302IA, Appendix C. Lengths are dictated by the panel width.
- 3. The load tabs are machined to the dimensions specified on Dwg. No. 7226-1302IA from 2024-T3 aluminum. The tab "blanks" have lengths equal to the basic laminate width. Test panels (fabricated using fiber-glass tabs) were tested to compare results for the aluminum tabs and to verify the use of aluminum tabs in the program. Figure 9 is a schematic of the alignment fixture which holds the specimens during splice and tab bonding. In Steps 4 through 8, below, reference is made to this schematic, by parenthetical number (X), to facilitate visualization of the layup sequence.

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4. The base plate (4) is placed on the metal bond fixture and the centering plates (6) are positioned on the locating pins, with the floating Teflon gap spacer plate (7) placed at the butt ends of the centering plates.



CODE

- 1 BORON LAMINATE ADHEREND
- 2 SPLICE PLATE
- 3 ALUMINUM TAB
- 4 BASE PLATE
- 5 SHIMS
- 6 CENTERING PLATES
- 7 0.020 GAP SPACER FLOATING

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- 8 FIXED SPLICE PLATE LOCATOR
- 9 FLOATING SPLICE PLATE LOCATOR
- 10 TAB LOCATOR
- 11 DAM
- 12 TAB ADHESIVE
- 13 SPLICE ADHESIVE

FIGURE 9 - ALIGNMENT FIXTURE FOR HOLDING SPECTIFIED FOR SPLICE AND TAB BOND

5. The lower aluminum tabs (3) are butted against the centering plates with shims (5) placed under the tabs to level the tabs with the top of the centering plates. The tabs are cleaned, metal bond etched and primed for bonding prior to installation (clean glove operation). The AF123-2, 0.06 lb/ft² wt. adhesive (12) is laid on the faying surface of the tabs.

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- 6. The laminates (1) with the peel plies removed* (clean glove operation) and the matching machined ends are positioned on top of the taps and centering plates. Dams (11) are installed at the outboard ends of the laminates adherend and held in position with locating pins.
 - *NOTE: The original group of specimens was prepared by sanding the bonding surfaces rather than using peel ply surfaces in attempt to obtain more uniform bondline thickness.

 This caused a wide variation in bond joint strength and was replaced with the more reliable peel ply surface preparation.
- 7. The upper aluminum tabs (3) are then prepared for bonding and the adhesive applied. They are placed in position butting the dam and the tab locators (10) are then positioned on the opposite ends of the tab and pinned in place.
- 8. The splice plate (2) is chemically prepared for bonding, primed, and adhesive (13), EA9601 0.06 lb./ft² wt., applied to the faying surface. The fixed splice plate locator (8) is pinned in place and the splice plate butted against it. The floating splice plate locator (9) is positioned on the opposite end of the splice plate.
- 9. Thermocouples are installed on the base plate adjacent to the part.

 Figure 10 shows a layup of three 12" X 18" bonded panel assemblies after installation of thermocouples just prior to initiating the bagging operation.



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FIGURE 10 LAYUP OF THREE 12" x 18" BONDED PANEL ASSEMBLIES

- 10. The assembly is bagged by laying two plies of 181 glass cloth bleeder over the part. The chain is used to distribute the air bleed from all portions of the layup to the tool exhaust port. The glass cloth bleeder extends past the chain and is taped to the tool surface. The remainder of the bagging procedure is described in Steps 10 and 11 of Section 2.2.
- The bagged assembly is then checked for leaks using 10" Hg vacuum. The assembly is installed in the autoclave and again vacuum is released, and the bag is allowed to stabilize at atmospheric pressure for 10 minutes. The pressure is then increased to 30 psig and the heat cycle started. The temperature is increased at a rate of 7°/minute ±2°/minute until the temperature reaches 250°F. The assembly is held at 30 psig ±2 psig and 250°F ±10°F from 60 to 90 minutes (75 minutes nominal). The part is allowed to cool down to 150°F under the 30 psig autoclave pressure. The pressure is then released and the autoclave opened.
- 12. The assembly is removed from the autoclave and the bonded panels removed from the tool, cleaned, visually inspected, and machined to the test specimen width dimension.

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- 13. Quality control check of the bonding operation is accomplished including metal finger panels which have been processed and primed along with the metal splice plates or adherends and laid up with the same adhesive batch and rool number as used for bonding the assembly. After bonding, these test coupons are tested to determine the lap shear properties of the adhesive system.
- 14. For machining, the panels are mounted on the table of a milling machine with the 0° fiber orientation lined up with the table axis. The slitting wheel is a 6" diameter by 0.032" thick wheel impregnated with 80-grit diamonds on the wheel periphery. The wheel is rotated at 1750 rpm. The table speed is set for 9"/minute when cutting boron, aluminum, or fiber-

glass and at 2"/minute for cutting titanium. The panel is kept flooded with water coolant during the slitting operation. The panel edge is trimmed 0.25" and the specimens are cut 1.00" wide by indexing the table 1.04" between cuts.

- 15. After machining, the specimens are checked for lipover of the splice plate which may obscure the bondline. By machining from the boron into the titanium, the lipover is not as pronounced, but some lipover is evidenced on all specimens, probably due to the wiping action of the trailing edge of the blade going in the reverse direction. In order to accomplish bondling measurements (as discussed in the Technical Inspection section), it is necessary to remove all lipover of the titanium. This is done by mounting the specimen on a surface grinder and taking light cuts with the wheel along the edge of the specimen.
- 16. The specimens are identified with the drawing number and specimen number and a data sheet is prepared (Appendix A) with pertinent information on the fabrication of the specimen.

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2.3.1 Phase II Fabrication - Configuration A

All 3" wide Configuration "A" specimens were prepared in a manner identical to that used for preparing the Phase I, Configuration "A" specimens, except for differences in final machined width. A typical specimen is shown in Figure 11.

2.3.2 Phase III Fabrication - Configuration A

The Phase III Configuration A specimens (10 inch wide single splice butt joint) were fabricated using the procedures developed under Phase I of this program. Bonded panels were fabricated 12 inches wide and 18 inches long. This size panel provided allowances for edge trim, a one inch wide control specimen and the required 10 inch wide Phase II specimen. A set of these specimens machined from one panel is shown in Figure 12.

Due to the width of this specimen, provisions had to be made for introducing end loads through bolted loading plates. For this purpose the tab configuration was changed from the basic constant thickness, 3-1/2" long aluminum tab to a stepped titanium tab. The stepped tab was fabricated by bonding an 0.018" titanium (8A1-1Mo-1V) sheet 3.5" wide, an 0.018" sheet 3" wide and an 0.035" sheet 2.5" wide such that the outboard edges of all three sheets were flush and the inboard end was stepped at 0.5" intervals. The titanium sheets were processed for bonding, primed and bonded together with FM123-4, .045 psf at 30 psig and 250°F to form a single prebonded tab. These tabs were then bonded to the ends of the specimens with the same adhesive system using 25" Hg vacuum and 225°F for two hours. These stepped loading tabs can readily be defined in Figure 12.

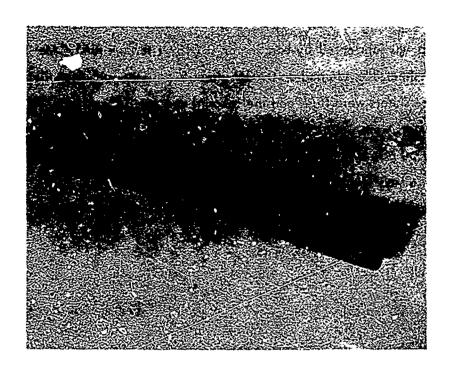


FIGURE 11 THREE INCH WIDE CONFIGURATION A SPECIMEN

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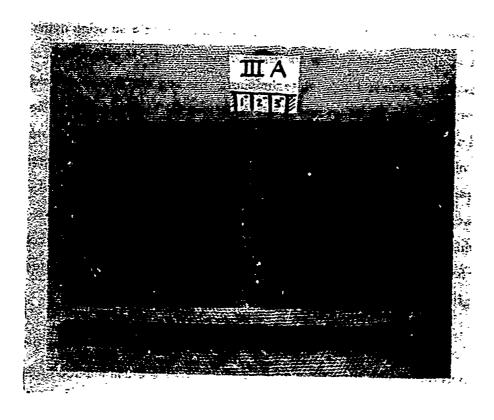


FIGURE 12 PHASE III CONFIGURATION A - SINGLE SPLICE BUTT JOINT

2.3.3 <u>Alternate Adherend Evaluation - Configuration A Fiberglass Specimens</u>

The fiberglass laminate required for these specimens was fabricated using 3M 1002 S glass prepreg tape (Batch L19, Roll W329). The laminate was a basic 8 ply $(0^{\circ}/\pm 45^{\circ}/0^{\circ})_2$ orientation, the same ply orientation as the baseline boron specimens, Dwg No. 7226–1302IA-IA. The lay-up techniques were comparable to those used for the boron panels fabricated previously under this contract. The laminate was laid up using nylon peel ply on both surfaces and a bleeder system consisting of one ply of 116 glass cloth. The assembly was bagged using standard bagging techniques. The bag was vacuum checked at 28" Hg vacuum for leaks prior to being sent to the autoclave for laminate cure. The autoclave run consisted of the normal vacuum check and the dwell at 10 psig for 10 minutes for stabilization after the vacuum was released prior to increasing the autoclave pressure to 50 psig. After stabilizing the autoclave pressure to 50 psig, a heat up rate of 7°/minute $\pm 2^{\circ}$ /minute was used in bringing the laminate up to the 350°F cure temperature. The part was held at this temperature and pressure for a minimum of one hour and then cooled to 150°F under full 50 psig pressure. Quality control specimens of 15 ply unidirectional laminates for flexural testing were laid up and cured with the laminate.

After quality control acceptance, the laminate was machined into two panels 9" X 15". These two panels along with the titanium splice plate and the aluminum load tabs were then prepared for bonding. The peel ply was removed from the fiberglass panel and the faying surfaces were sanded and cleaned before application of adhesive. The metal elements were cleaned and primed in the same manner as used previously for the boron specimens. Adhesive was applied to all surfaces requiring a bond and the assembly was laid up and bonded in the standard autoclave procedure used for previous Configuration A specimens. All bond lines used EA9601, 0.06 lb./ft² weight, adhesive cured at 250°F for one hour under 30 psig autoclave pressure.

After bonding, this panel was machined into 1" widths, thus providing 14 fiberglass-to-titanium Configuration A specimens. All specimens were then submitted for inspection and testing.

2.3.4 Alternate Adherend Evaluation - Configuration A Graphite Specimens

The graphite laminate required for these specimens was fabricated using Fiberite Hy E 1311B graphite/epoxy tape (Lot No. 1088, Roll No. 1). The laminate was laid up as an 8 ply, 0°/±45° balanced lay-up identical to that used for the baseline boron/epoxy bonded joint specimens. Lay-up procedures and bagging techniques were the same as previously used on boron and fiberglass laminate. Two plies of 116 fiberglass cloth were used as the bleeder system. Nylon peel plies were incorporated on all bonding surfaces. The standard vacuum bag was used over the laminate and was checked for leaks at 28" Hg vacuum. The autoclave cycles used to cure the graphite epoxy was recommended by the supplier and is outlined below:

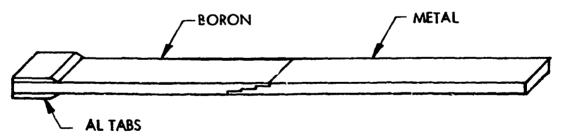
- 1. Apply vacuum of 28" Hg and recheck for leaks.
- 2. Hold vacuum and increase temperature to 200°F at a rate of 3-5° per minute.
- 3. Hold at vacuum and 200°F for 15 minutes.
- 4. Release vacuum and increase autoclave pressure to 85 psig.
- 5. Hold at 85 psig and 200°F for 60 minutes.
- 6. Increase temperature to 300°F at 3~5°F per minute and hold at 300°F for 60 minutes.
- 7. Increase temperature to 375°F at 3-5°F per minute.
- 8. Hold at 375°F and 85 psig for 240 minutes.
- 9. Cool to 150°F under 85 psig.

A 15-ply unidirectional quality control panel was laid up and cured with the laminate for subsequent acceptance testing. After quality control acceptance the laminate was machined into two panels 9" X 15". These two panels, the titanium splice plate and the aluminum load tabs were prepared for bonding. Preparation for bonding and bonding procedures were the same as used for the fiberglass panel. As with previous specimens the adhesive used was EA 9601 0.06 lb./ft. weight which was cured at 250°F for one hour under 30 psig autoclave pressure.

After bonding, the panel was machined into 1" widths, thus providing 14 graphite-to-titanium Configuration A specimens. All specimens were then submitted for inspection and testing.

2.4 JOINT FABRICATION - CONFIGURATION B, BORON TO METAL STEPPED SINGLE SCARF

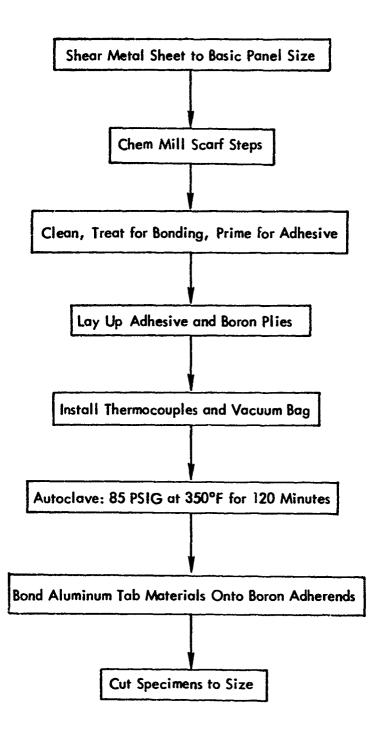
The Configuration B specimens were fabricated utilizing the co-curing process, i.e., curing the laminate and bonding to the metal adherend during one operation. These specimens are illustrated in Figure 2 which is repeated below. Individual specimens were fabricated according to the requirements of Dwg. No. 7226-1302IB, Appendix C.



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Size: Approx. 18" X 1" width (Phase I, illustrated)

FIGURE 2 - CONFIGURATION "B"
BORON TO METAL STEPPED SINGLE SCARF JOINT



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FIGURE 13 - STEP CHART FOR CONFIGURATION "B" SPECIMENS

The steps and procedures followed to produce good quality joints by this process are listed below:

- 1. The titanium (6A1-4V annealed) and aluminum (7075-T6) are sheared from 0.084" thick sheet into basic panel size per Dwg. No. 7226-1302IB, Appendix C.
- 2. Due to the warpage generated in mechanically milling the steps on the metallic adherends, the steps are milled chemically. The metal is masked and the steps are generated by raising the metal sheet the required height for the step length after the material from the first step has been removed. Each of the three steps are milled in this fashion. A trim allowance was left on the final step so that it could be cleaned up by machining off the ragged edge generated in the chemmilling process. A radius was left in the corners of the steps varying from 0.010" to 0.030' for the first to the last step, respectively. The chem-milling was held within the ±0.002" specified on the drawing.
- 3. After machining, the chem-milled panels are recleaned, chemically treated for bonding, and primed with the adhesive primer.

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- 4. The adhesive, EA9601, 0.045 lb/ft² weight, is laid up on the steps of the joint. The metal adherend is placed on the tool with a sheet of Mylar film and Teflon-coated glass between the part and the tool surface. Four plies of boron are laid up butting the edge of the first step. Four additional plies are laid up over the first step and butting the end of the second step. This layup is continued with four plies of boron per step until all steps were covered. The orientation of the laminate is specified on Dwg. No. 7226-13021B.
- 5. The bagging and curing procedures of these panels are identical to those described for the basic laminate fabrication (Section 2.2, Step 5 through Step 16). The metal portions of the specimens are covered with Teflon tape to prevent resin build-up during the cure cycle and the bleeder system covers only the boron laminate portion of the panel.

- 6. The boron adherends are tabbed with the aluminum tab materials in a secondary bonding operation.
- 7. The specimens are cut to size using the same techniques as described for the Configuration "A" specimens (refer to Section 2.2, Steps 14 and 15). See Figures 14 and 15.

2.4.1 Phase II Fabrication - Configuration B

Fabrication of the 3 inch wide Configuration B specimens (boron-to-metal step scarf joint) is detailed below.

The basic 6A1-4V titanium sheet (9" X 13") used for the Configuration "B" specimens was 0.084" in thickness. The titanium was chem-mill masked over all areas where the metal was not to be removed. The nominal basic steps that were chem-milled are 0.020" in depth with step lengths of 0.500" and 0.375". The protective mask was removed in incremental steps as required to obtain the three required step lengths and depths. The specimen was checked periodically during the chem-milling process to verify proper material removal and to assure acceptable step depths.

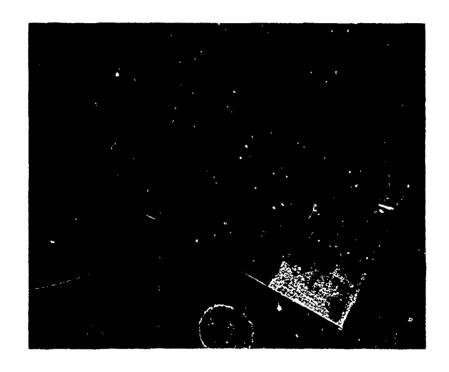
After the chem-milling process was completed, the titanium was prepared for metal bonding. The treatment used for titanium preparation was in accordance with paragraph 6.1.6 of MIL-A-9067C. The basic steps were solvent wipe, vapor degrease, acid pickle, water rinse, phosphate/flouride immersion, water rinse, hot water soak, distilled water spray, and air dry. The areas to be bonded, i.e. the steps, were primed with EA 9201 primer immediately after completion of the titanium surface treatment. The adhesive, EA 9501-045 psf, was then applied to the faying surfaces and the boron was laid up with 16 plies, 0° ±45° orientation. The total assembly (13" X 18") was cocured at 85 psig and 350°F for 2 hours.

Similar procedures were followed in the preparation of the 7075-T6 aluminum/boron step joint specimens. The metal bond preparation for the aluminum was the normal metal bond etch followed by immediate priming with the EA 9201 primer. The boron half of the cured specimen panel was tabbed using aluminum tabs. The same procedures were used in bonding the tabs as previously described for the Configuration "A" specimens.

The cured panels were then cut into 3" wide specimens and submitted to Quality Assurance for checking the titanium/boron and aluminum/boron bond lines for both integrity and thickness. A typical specimen is shown in Figure 16.

2.4.2 Phase III Fabrication - Configuration B

The ten inch wide Phase III Configuration B specimens (boron-to-metal step scarf joint) specimens were fabricated in the same manner as discussed for the Phase II, 3-inch wide specimens. Bonded panels for these specimens were fabricated 12 inches wide thus providing sufficient width for a 10-inch wide fatigue specimen, a one inch wide control specimen and edge trim. Machined specimens are shown Figure 17.



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FIGURE 14 BONDED PANEL ASSEMBLY CONFIGURATION "B" SPECIMENS

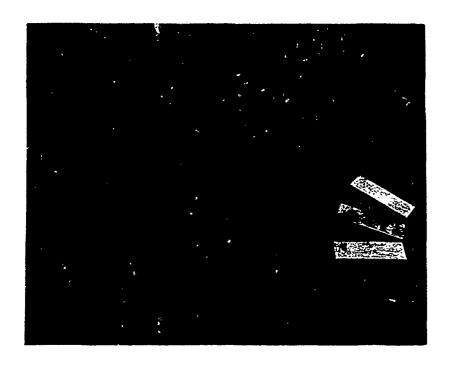


FIGURE 15 MACHINED CONFIGURATION "B" SPECIMENS

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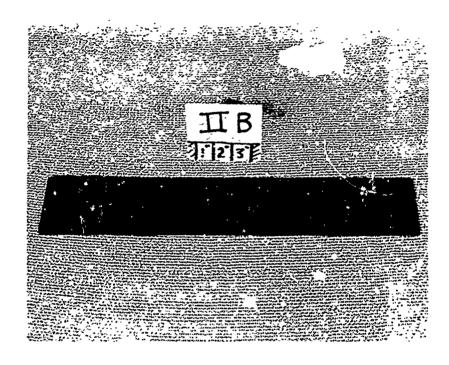
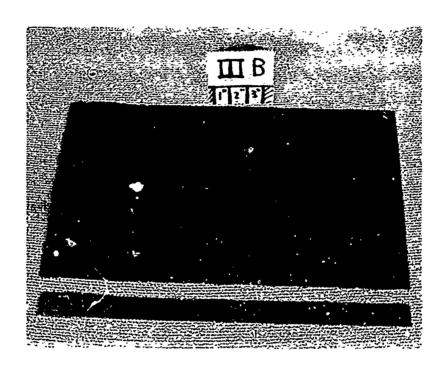


FIGURE 16 PHASE IF CONFIGURATION B - STEP SCALE BONDED JOINT



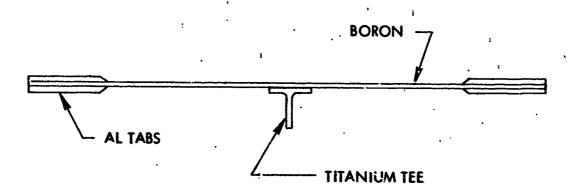
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FIGURE 17 PHASE III CONFIGURATION B - STEP SCARF BONDED JOINT

2.5 JOINT FABRICATION - CONFIGURATION C, SURFACE TO UNDERSTRUCTURE ATTACHMENT, BONDED

The Configuration C specimens were fabricated using precured laminates made as described in Section 2.2. These specimens are illustrated in Figure 3, which is repeated below. Individual specimens were fabricated according to the requirements of Dwg. No. 7226-130IC, Appendix C.



Size: 18" X 1"

FIGURE 3 - CONFIGURATION "C"
SURFACE TO UNDERSTRUCTURE ATTACHMENT - BONDED

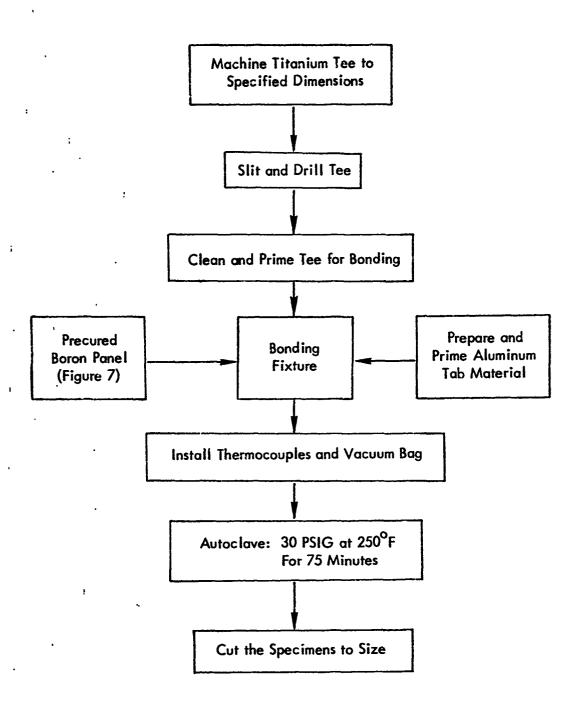


FIGURE 18 - STEP CHART FOR CONFIGURATION "C" SPECIMENS

The following steps and procedures were taken to maintain uniformity and quality of the bond joint between the metal "tee" and the boron laminate:

- 1. A tilanium tee extrusion (6Al-6V-2Sn) is machined to the cross-sectional dimensions specified on Dwg. No. 7226-1302IC (Appendix C). The tee is then slit across the leg and into the cap, allowing for the 1.00" width between cuts and leaving 0.06" on the cap for continuity. The slitting is done to minimize the machining of titanium after bonding. Holes are drilled 0.50" from the end of the leg and centered between the s!its.
- 2. The titanium is chemically cleaned and primed for bonding.
- 3. The aluminum tab material is cleaned, metal bond etched, and primed for bonding.
- 4. The lower tabs are positioned on the bonding fixture and the AF123-2, 0.06 lb/ft² weight, adhesive is laid on the faying surface.
- 5. A precured panel with the proper ply orientation is cut the required size to produce the specified number of specimens. The peel ply is then removed from the boron panel and the panel positioned over the lower tabs.

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- 6. The upper tabs are covered with the AF123-2, 0.06 lb/ft² weight, adhesive and are positioned using the pinned tab locators.
- 7. The primed titanium tee is prepared for bonding by applying the EA9601, 0.06 lb/ft² weight, adhesive to the upper cap surface which is then inverted and positioned on the boron laminate. The cap is held in place using splice plate locators and spacers to compensate for the width variation of 0.27" between the tee cap and the splice plate.
- 8. Conventional bagging techniques are used in bagging over the tee section. Plies of fiberglass cloth are laid up to round off the area on either side of the upstanding leg of the "tee".

- 9. The procedures outlined for bagging and curing the Configuration "A" specimens (Steps 9–13) are followed for this bonding operation.
- 10. For machining the panel into 1.00" specimens, the procedures outlined for machining Configuration "A" specimens (Steps 14 and 15) were followed. The saw cuts in the titanium are used as indexing points for cutting the laminate, tabs and the balance of the titanium tee. Since the original cut in the titanium is 0.090" wide and the diamond saw cut is 0.040" wide, the specimens are set up on a surface guider to machine the 0.025" excess off from each side of the laminate.
- 11. After visual inspection, the specimens are identified with the drawing number and specimen number, and a data sheet is prepared (Appendix A) with pertinent information on the fabrication of the specimen. Specimens are shown in Figures 19 and 20.

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FIGURE 19 THREE CONFIGURATION "C" SPECIMENS

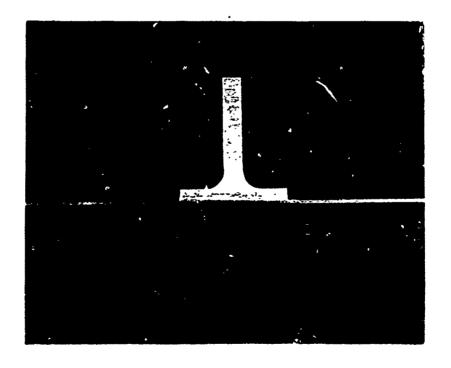
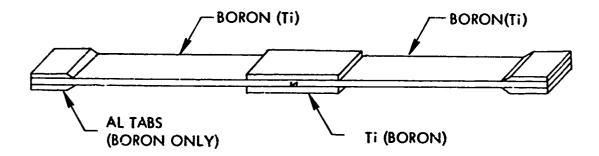


FIGURE 20 EDGE VIEW OF CONFIGURATION "C" SPECIMEN

2.6 JOINT FABRICATION - CONFIGURATION D, DOUBLE SPLICE BUTT, BONDED

Configuration "D" specimens were fabricated according to the requirements of Dwg. No. 7226–1302ID, Appendix C. The same procedures were followed in fabricating the Configuration "D" specimens as were used for Configuration "A". Tooling was modified to allow for the location of the lower splice plate directly under the upper splice plate. Provisions for keeping the adhesive from flowing between the butt ends of the adherends were not made for the "D" specimens, since the presence of adhesive in this area is not deemed detrimental to the required tension-tension testing. The upper splice plate was located using the normal splice locators as discussed for Configuration "A". Configuration "D" specimens were made both with boron joined adherends (main load plates) matched with titanium splice plates, and with titanium joined adherends matched with boron splice plates. These specimens are illustrated in Figure 4, which is repeated below.



Size: Approx. 18" X 1"

FIGURE 4 - CONFIGURATION "D" DOUBLE SPLICE BUTT JOINT - BONDED

2.7 JOINT FABRICATION - CONFIGURATION E, SINGLE SPLICE BUTT, BOLTED

These specimens are illustrated in Figure 5, which is repeated below. Individual specimens were fabricated according to the requirements of Dwg. No. 7226-1301E, Appendix C.

Configuration "E" Single Splice Butt Joint - Bolted
Size: Approx. 18" X 1" width (Phase I, illustrated)

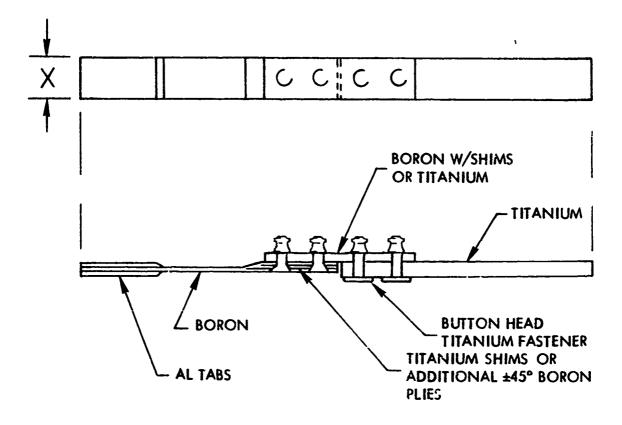


FIGURE 5 (REPEATED)

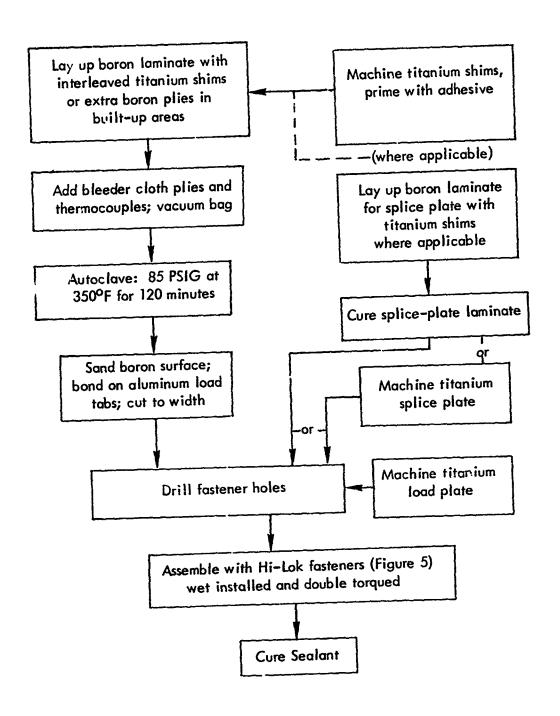


FIGURE 21 - STEP CHART FOR CONFIGURATION "E" SPECIMENS

The lay-up procedure for the basic boron panel laminate thickness for the composite side of the Configuration E specimens was similar to that described in Section 2.2. The boron plies were laid up in large sheets with the specimen details cut to length and width after the laminate had been cured. However, since the mechanical joints require additional built-up areas for providing the bearing strength to reach the fastener loads, these build-ups were incorporated in the ends of the laminate during the lay-up operation.

The build-ups were achieved either by interleaving tetanium shims or additional pairs of ±45° boron plies among the basic laminate plies. See Drawing 7226-13021E in Appendix C for exact stacking sequences. The additional shims or plies were staggered in length to provide a smooth transition from the basic laminate to the build-up area. Prior to lay-up, titanium shims were machined to size, processed for bonding, and primed. The primed titanium shims were then overlaid with 0.045 kb./ft² weight EA9601 adhesive and placed in the laminate as required.

The resin bleeder system and the bagging procedures 'ollowed were similar to those used for the Basic Laminate Panels, Section 2.2, except that no peel plies were used. An autoclave cycle of 85 psig and 350°F for 120 minutes was employed. Quality control specimens were included with the panel lay-up to verify the material properties.

After cure, the laminate was cut with a diamond saw into panels 9 inches long and of sufficient width to provide 9 to 24 one-inch-wide specimens. The load grip ends of the panel were tabbed with aluminum tabs. The boron surface was sanded, the aluminum tab material was metal bond etched and primed, adhesive was placed between the aluminum tabs and the boron, and then the assembly was bagged and cured at 250° F for 60 minutes under 20" Hg vacuum. The panels were then cut into specimen details 1" wide by 9" long using a diamond saw on a milling machine. Excess coolant was used and the mill feed rate was decreased when the cut was made through the titanium-boron build-up area to reduce the possibility of laminate overheating.

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The titanium joint details were machined 1" x 9" to form the second half of the joint. Also, the titanium splice plates or boron-titanium shim splice plates were machined to 1" width and to the length necessary for providing the required edge distance for the fasteners. Specimen components prior to assembly are shown in Figure 22.

The holes for the fasteners were drilled using a diamond core drill. No problems were encountered in drilling the boron-boron laminates. However, considerable difficulties were encountered in drilling the boron-titanium specimens.

In order to provide quality holes for these specimens, it was necessary to change tools during the drilling operation. This was done on a milling machine using a core drill for the boron and an end mill for the titanium. This procedure eliminated overheating of the specimen during drilling and provided a hole free from lip-over in the titanium which results from a one step diamond drilling operation. Good back-up of the laminate was used to prevent fiber breakout on the back side of the hole. The holes were countersunk using diamond countersinks. No problems were encountered and all countersunk holes had good visual surface characteristics. The specimens were spot checked by ultrasonics to determine if any delamination occurred during drilling and none was found.

Specimens were assembled using Hi-Lok fasteners. The fasteners were wet installed and the faying surfaces were coated with a sealant in accordance with standard assembly procedures for mechanically fastened joints. The fasteners were torqued to 30 inchpounds ±1 inch-pound and re-torqued after approximately 30 minutes to account for any squeeze-out of the faying surface sealant. The assembly was then baked for 48 hours at 160° F to cure the sealant. Three completed joints are shown in Figures 23 and 24. The three specimens shown represent thick laminate-to-metal, thin laminate-to-metal and laminate-to-laminate combinations.

Initial fatigue tests of the Configuration E specimens, composite-to-metal mechanical joint, resulted in failure of the metal portion of the joint. A number of attempts were made to correct this deficiency. The first attempt replaced the 7075-T6 aluminum

portion of the joint with 8Al-1Mo-iV titanium of equal thickness but these specimens failed in the countersunk portion of the titanium. This led to the replacement of the BL19PB6 flush head fasteners by HL18PB6 button head fasteners for the metal-to-metal portion of the joint but this only moved the failure to the titanium splice plate.

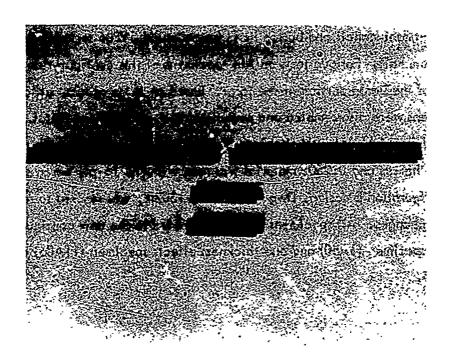
This second failure mode led to the final design which consisted of the boron portion joined to 8Al-1Mo-1V titanium which was 50 percent thicker than the composite.

These specimens were assembled with flush head fasteners, HL19PB6 series, used on the boron-to-titanium half and button head fasteners, HL19PB6 series, used on the titanium-to-titanium half. Fatigue tests on two specimens of this configuration resulted in fatigue failures of the boron portion of the joint. Based on these results, all of the Configuration E specimens were disassembled and new metal splice plates and metal joint halves were machined from 8Al-1Mo-1V titanium; 0.125" material was used with the 8-ply boron specimen halves and 0.250" material was used with the 16-ply boron specimen halves.

The Configuration E design, Dwg. No. 7226-1302IE, was revised to reflect these required changes. All specimens were reassembled to the new configuration. One baseline specimen (1A60) and one thickness effects specimen (11A06) are shown in Figure 25.

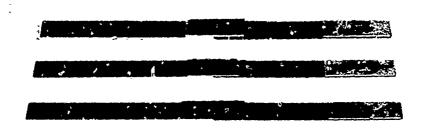
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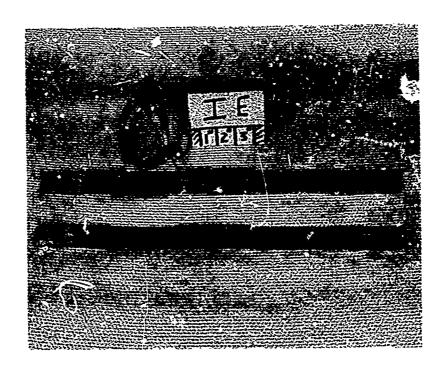
:FIGURE 22 CONFIGURATION E SPECIMEN DETAILS



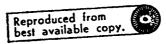
FTGURE 23 CONFIGURATION E COMPLETED SPECIMENS



FIGURE 24 CONFIGURATION & JOINT CLOSE-UP



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FIGURE 25 CONFIGURATION E - MECHANICAL JOINTS

2.7.1 Phase II Fabrication - Configuration E

The laminate portions and splice plates for these specimens were identical to the Phuse I Configuration specimens in materials, thicknesses, and configurations except that they were wider. Phase II specimens were two inches wide and contained two rows of fasteners, whereas the Phase I specimens were one inch wide and contained only one row of fasteners.

All specimens were match drilled and countersunk in the boron. Flush head fasteners were used on the boron to splice plate portion of the joint, and button head fasteners were used on the splice plate to loading plate portion of the joint. All fasteners were wet installed with double to quing operations to account for relaxation of fastener torque due to sealant squeeze-out.

Photographs of failed specimens are included in the TEST PROGRAM section of this report.

2.8 JOINT FABRICATION - CONFIGURATION F, SURFACE TO UNDERSTRUCTURE - MECHANICAL

These specimens are illustrated in Figure 6, which is repeated below. Individual specimens were fabricated with one of two laminate thicknesses according to the requirements of Dwg. No. 7226-130IF, Appendix C.

Configuration "F" Surface to Understructure Attachment - Mechanical
Size: 18" X 1" width

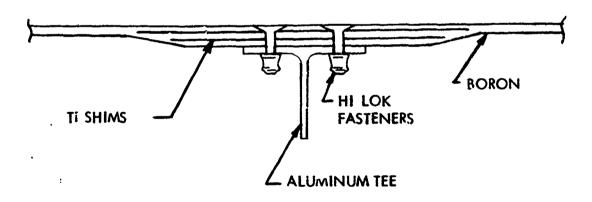
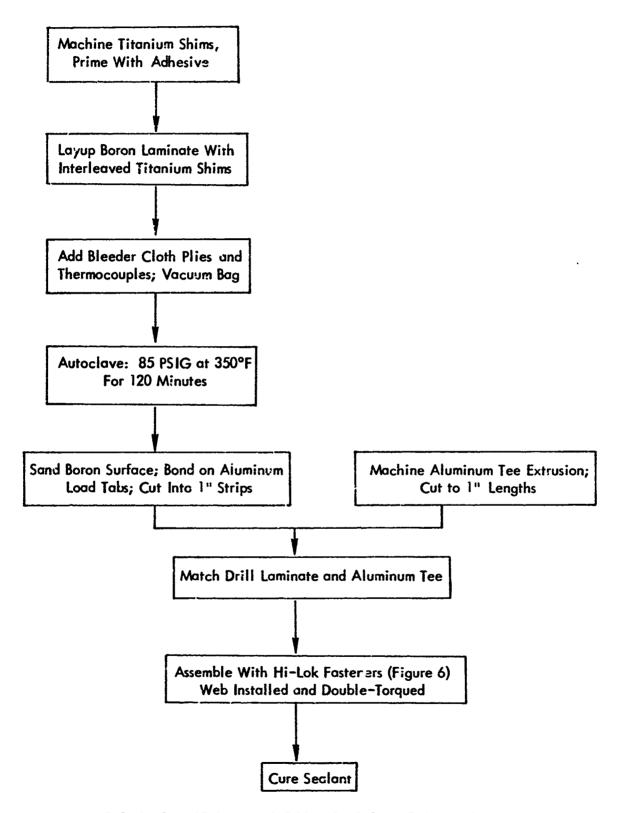


FIGURE 6 (REPEATED)



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FIGURE 26 - STEP CHART FOR CONFIGURATION "F" SPECIMENS

Laminates were laid up and fabricated according to the size, orientation, and requirements of Dwg. No. 7226-1302IF, Appendix C. Panels contained either 8 or 16 boron plies of 0°/±45° orientation. The 8-ply panels had titanium shims of 0.012" thickness sandwiched between the second and third, and the sixth and seventh boron plies. The 16-ply panels had titanium shims between the second and third, sixth and seventh, tenth and eleventh, and fourteenth and fifteenth plies.

The shims were staggered in length to provide a smooth transition from the build up area to the 'asic laminate. Prior to layup, titanium shims were machined to size, processed for bonding, and primed. The primed titanium shims were then overlaid with 0.045 lb./ft² weight EA960' adhesive and placed in the laminate as required.

The resin bleeder system and the bagging procedure followed were similar to those described in Section 2.2 except that no peel plies were used. Panels were cured in an autoclave cycle of 85 PSIG and 350°F for 120 minutes. After cure the laminate surface was sanded and primed aluminum tab material was applied in a secondary bond operation (250°F for 60 minutes under 20" Hg vacuum). The laminate was then cut into 1" strips.

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The aluminum tee was machined into the required one-inch long sections and match drilled with the laminate. Holes through the boron/titanium shim laminate were generated with a core drill and final sized with a diamond reamer. The laminate was countersunk with a diamond tool and the specimen was assembled using flush head fasteners, HL19PB6 series, wet installed. Fasteners were initially torqued to the required 30 inch-pounds and after 30 minutes were torqued again to 30 inch-pounds to account for any relaxation due to squeeze-out of the faying surface sealant. The assembly was then baked for 48 hours to cure the sealant.

Photographs of failed Configuration F specimens are included in the TEST PROGRAM section of this report. These photographs show a close-up of the joint area.

SECTION III

TECHNICAL INSPECTION AND QUALITY ASSURANCE

3.1 INTRODUCTION

This section contains the information related to nondestructive inspection of the fatigue phenomenon investigation specimens, destruct test verification of the base filamentary composite materials, and process and material assessment testing and evaluations. A description of techniques, summary of test data, and presentation of findings are presented below. An itemized listing of associated data are presented in Appendices A, B, and C.

3.2 NONDESTRUCTIVE EVALUATION OF BONDED COMPOSITE JOINTS

The nondestructive evaluation of the bonded joints in this investigation was intended to detect conditions apparent using current state-of-the-art techniques including ultrasonic, visual, microwave, and radiography methods where applicable. The plan by which the evaluations would be accomplished war imarily to:

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- o Determination of the detrimental conditions which must be nondestructively evaluated
- o Determine which acceptable conditions affect the evaluation data in the same manner as the aforementioned
- Utilize specific nondestructive evaluation disciplines and techniques to detect the unwanted conditions

Although the evaluation was expected to detect conditions such as disbonds, delaminations, fiber separation, inclusions, porosity, cracks and bondline thickness variation, additional information was gained during the investigation. This information has been used to reestablish the relative effectiveness of some NDE disciplines in composite evaluations and to recommend factors to be considered in future work.

Since there are many defects which can affect the quality of a bonded joint which varies in nature and characteristics, no single nondestructive test can be expected to evaluate a composite joint for all defects. Ultrasonics, x-ray, microwave and visual tests have

each been used to assure a full evaluation of the bond joint. The preferred test method appears to be ultrasonics since this procedure detected most of the defect conditions and provided additional information yielded by the attenuation of sound in the specimen.

Initially the intention was to detect a defect in the specimen with the ultrasonic procedure, then define the location of the defect with x-ray laminography. Laminography is a relatively new technique of radiography which allows an incremental radiographic analysis of a thin section within a thick sample without physically sectioning the sample. The analysis is accomplished by averaging the unwanted image over a large area while the image of interest remains defined. This result is achieved by synchronously rotating both the film and the sample during the exposure. After examining several joint specimens with this system, it was determined that conventional radiography would provide adequate information for this program.

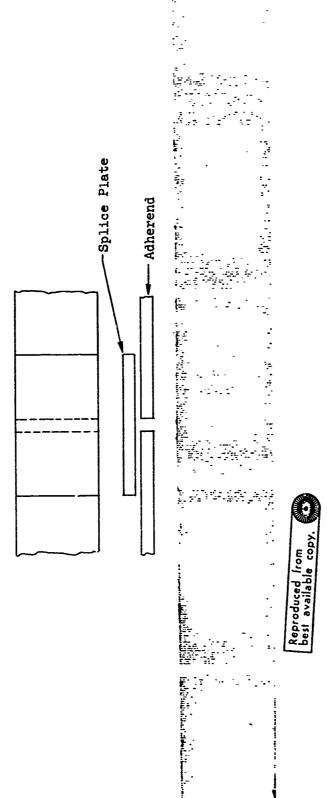
A more detailed discussion of each of these inspection methods is given in the following paragraphs.

3.2.1 Ultrasonic Inspections

All ultrasonic evaluations were performed with an immersion pulse-echo technique. A permanent C-scan recording as in Figure 27 was made for all joints evaluated ultrasonically. The equipment, shown in Figure 28, with which the inspections were made, is a Sperry Immersion C-scan System, Reflectoscope Model UM 721.

The immersion technique used measures variations in ultrasonic attenuation (loss of sound) as the sound traveled through the specimen to a mirror then back through the specimen to the part. The recorder was activated by preset strength levels of the returning ultrasonic energy as shown in Figure 29. The attenuation contributed by the water in the immersion tank and the mirror was assumed to be constant throughout this investigation.

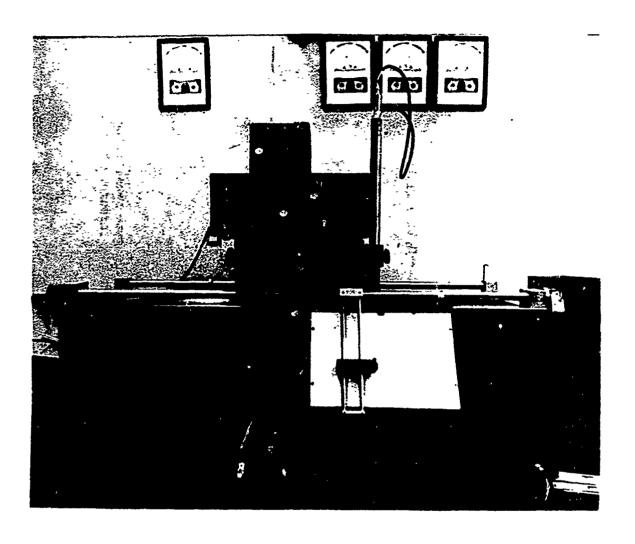
Attenuation is increased by the presence of variation in consistency such as the following defects: porosity, disbonds, inclusions, voids (gross porosity), delaminations, specimen surface roughness, bondline thickness, and resin-starved areas of the composites.



Joint specimens are scanned five times at various gate sensitivity levels. Dark areas indicate less sound is getting through. Sensitivity is decreasing from left to right.

FIGURE 27 - TYPICAL C-SCAN RECORDING

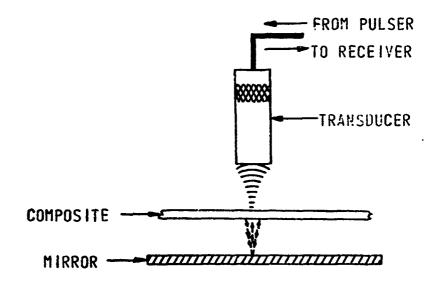
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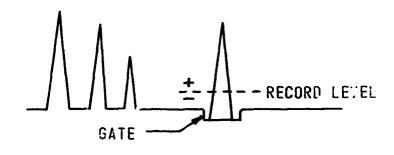


Specimens are immersed in water and scanned automatically using the pulse-echo technique. Recordings are made of all inspections.

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FIGURE 28 - ULTRASONIC C-SCAN INSPECTION SYSTEM





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FIGURE 27 - PULSE-ECHO TECHNIQUE

- 3.2.1.1 Disbonds, Voids, Delaminations These conditions completely stop penetration of ultrasonic energy through the specimen if the defect size is greater than the .117 square inch area of the ultrasonic energy beam impinging on the specimen surface. Of course the energy transmitted will be proportional to the inverse of the area above. The larger defect will be outlined on the C-scan plan recording. These conditions were rated as go or no-go since normally, if any voids, etc., exist, the specimen was usually completely bad. The evaluation was described as go or no-go since the sound is either transmitted through the specimen or completely stopped.
- 3.2.1.2 Porosity Inclusions The effective sound blocking area of these conditions was usually less than the area of the sound beam impinging on the specimen surface. Porosity in sufficient concentration to completely block all sound could be visually detected at the edge of the bondline. Adequate in-process control can eliminate the porosity such that no significant decrease in kondline strength results. Inclusions were classified in the same evaluation category as porosity. Radiography was used to detect inclusions.

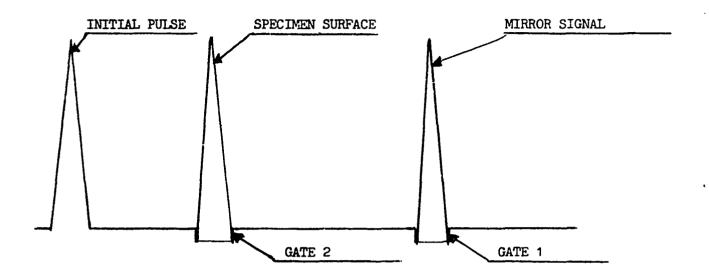
The effect of these two conditions was not considered on the C-scan read-out unless:

- o The porosity was visually detected during bondline measurements.
- o Radiographic inspection detected foreign material in the bondline or composite.

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The attenuation of the ultrasonic energy was attributed to other conditions if the aforementioned did not exist.

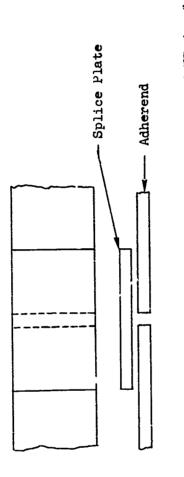
3.2.1.3 Surface Roughness - This condition, while not always considered defective, had an adverse effect on the energy returning to the transducer. The rough surface scattered the sound away from the main beam, therefore the returning sound energy was lessened. The returning signal (Figure 29)decreased in amplitude and was printed on the C-scan chart as a high attenuation area.

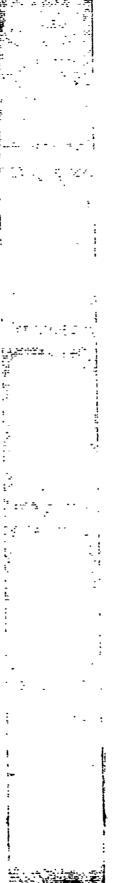


This illustrates the signal reflected from the specimen surface. The signal magnitude, affected by the surface roughness, can be gated to give some measure of energy scattered away from the sound beam.

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FIGURE 30 - ULTRASONIC SIGNAL PRESENTATION ON CATHODE RAY TUBE.

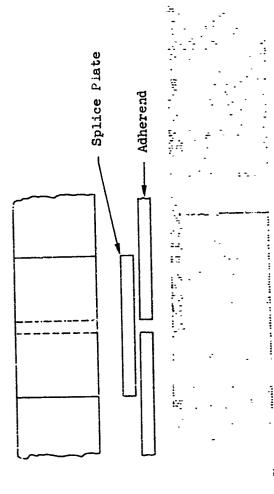




This recording was made prior to fatigue testing. The specimen failed on the left side during test. There was a noticably less amount of sound transmission on the left side which is particularly evident on the third and fourth sensitivity levels from the left. Sensitivity is decreasing from the right.

FIGURE 31 CLSCAN RECORDING OF TYPICAL JOINT SPECIMEN

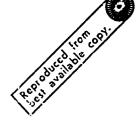
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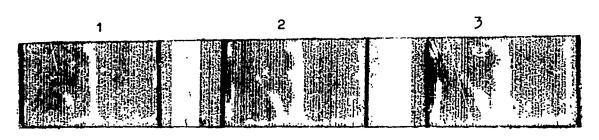


This recording was taken from a group of specimens which were not fatigue tested due to a poor bond. Notice the lack of sound transmission at all sensitivity levels.

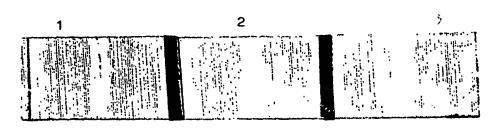
FIGURE 32 C-SCAN LECORDING OF POORLY BONDED JOINT

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ULTRASONIC C-SCAN RECORDING C-scan of Graphite Joint G9A. Low sound transmission shown as white area.



ULTRASONIC C-SCAN RECORDING C-scan of Fiberglass Joint FG7A. Low sound transmission shown as white area.

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* Gate level above samples denotes sensitivity to low sound transmission areas wherein 1 is least sensitive.

FIGURE 33 C-SCAN RECORDINGS FROM GRAPHITE AND FIBERGLASS COMPOSITE JOINTS

This problem was eliminated by a close visual inspection which revealed any wide variation in surface roughness among the specimens. However, the visual inspection did not represent an actual measurement. A measurement can be accomplished using the first interface signal (reflection from the part surface) shown in Figure 30. This signal decreased in strength as the surface roughness increased. The surface roughness would not be a factor if the inspection was intended to detect only voids, delaminations or disbonds. It must be considered as a factor however if any future investigations are to be made to determine the strength of a bonded joint.

3.2.1.4 Bondline Thickness - Sound transmission was inversely proportional to bondline thich less. This was noted on some samples wherein the bondline was .001 inch thicker or one side of the joint specimen. At extremely high sensitivity (low energy level) the sound attenuation dropped appreciably in the thick bondline area.

This measurement would be a critical factor in any investigation to determine the strength of a bonded joint. At the high ultrasonic energy levels used in this investigation it was not a significant factor.

3.2.1.5 Summary of Test Results - Only one group of specimens were rejected using the ultrasonic system and these specimens did not undergo fatigue testing. A C-scan representing a typical specimen from this group is compared with a good joint in Figures 31 and 32.

Ultrasonic analysis of the joints gave a better overall evaluation of the specimens than any of the other NDE disciplines. Sufficient data was accumulated to affect the techniques used in the evaluation of bonded joints in future investigations.

C-scans were also made of graphite and fiberglass joint specimens. The recorder was adjusted to print good areas thus high attenuation areas were the light or white areas (Figure 33). A lower energy amplification level was noted on the graphite specimens than that required to obtain similar energy transmission levels for the fiberglass and boron specimens. This would indicate better sound transmission through the graphite specimens. The gain level was adjusted to have comparable C-scans of all specimens.

This lower energy level requirements was due in most part to two conditions found in these specimens: first, the thinner bond lines in these specimens which attenuated the sound less and second, the smoother graphite surfaces. The surface roughness was much greater in the boron specimens, which scatters the impinging sound, thereby decreasing the energy received by the transducer. The roughness is attributed to use of a fiberglass peel ply (181 style cloth) and to the large boron filance such also scatter the sound energy as it travels through the laminate and joint. A comparison between the C-scans for fiberglass and graphite joints having the same bondline thicknesses shows more sound transmission through the graphite than the fiberglass specimens. Again the surface roughness of the fiberglass specimens was greater. A comparison of C-scans of specimens at the extreme ends of the thickness range showed slight differences in sound transmission.

3.2.2 Radiography Inspections

X-rays were made of joint specimens to detect porosity, fiber orientation, foreign material and cracks. Radiography was accomplished with a TORR Laboratories Type TX-360 unit with the following specifications: 0-120 KV, 3 or 5 ma, 0.15 inch Beryllium window and a 0.35 mm focal spot size. The equipment is shown in Figure 34.

3.2.2.1 Defect Conditions – These conditions illustrated in Figure 35, can generally be defined as or related to:

- o Foreign Material This is defined as any extraneous matter which does not resemble the surrounding material in structure or form.

 The image will appear on the radiograph as a less dense (light) sharply defined object.
- o Fibe. Spacing The distance between two adjacent parallel fibers.

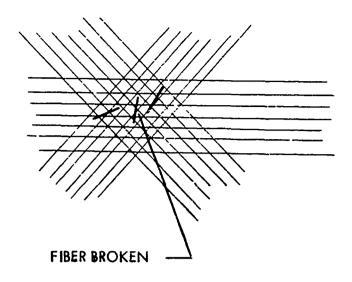
 This distance will generally be approximately 0.004 inches.
- o Fiber Orientation The direction fibers are running in a ply. An abnormal condition will exist when one or more fibers run unparallel to the normal direction.
- o Fiber Breakage Small lengths of fibers dispersed throughout the composite.

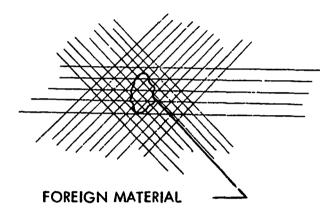


The x-ray source is shown on the right.

The fixture shown on the left is the laminography specimen plate and film holder. The cabinet is being utilized for both conventional radiography and laminography.

FIGURE 34 - X-RAY SOURCE





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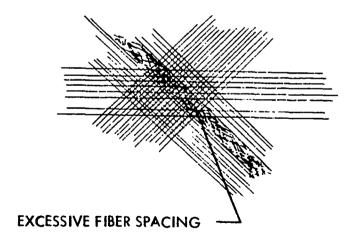


FIGURE 35 DEFECT CONDITIONS IN FILAMENTRY COMPOSITES

- 3.2.2.2 Surmary of Test Results Radiographs were taken of 713 joint specimens.

 No condition severe enough to reject any specimen was detected. However, the preceding conditions were found in many specimens noted as follows:
 - o Fiber Breakage Broken fibers were found in 278 specimens. The fibers were either scattered throughout the joint or concentrated at the edge.
 - o Fiber Spacing Samples in which some fibers exceeded .004 inch spacing between parallel fibers totalled 36.
 - o Fiber Orientation Lack of parallelism was noted among very few fibers in 42 specimens.
 - o Foreign Material This condition was detected in 29 samples.

Unknown conditions indicated by abrupt changes in density were noted in 6 specimens. This may be an indication of thin bondline or light porosity.

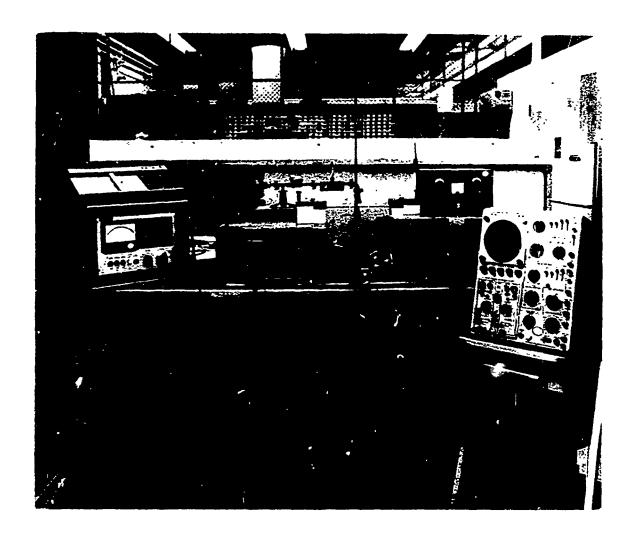
Some specimens exhibited two of the above conditions. One or more of the defect conditions were detected in 373 of the 713 evaluated specimens. No correlation could be noted between the x-rays and the ultrasonic C-scans.

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3.2.3 Microwave Inspections

Microwave testing was accomplished with Microdac Model 664 instrumentation and a Lockheed built Structural Integrity Tester (Figure 36). The tester was a swept frequency square wave generator with a range of 30 Hz to 3.2 kHz. The generator was used in conjunction with a vibrating solenoid to provide a mechanical energy input into the joint specimens. The microwave unit was used to analyze the resultant specimen vibration and determine the resonant frequency. The resonant frequency is a function of the stiffness of the specimen. It was hoped that this would also be a measure of joint quality.

Post fatigue inspection of sixteen joint specimens showed a significant drop in resonance frequency for all specimens tested. This was considered to be significant to warrent further investigation to determine the cause. In so doing it was discovered that the holding



The microwave vibration detector is shown on the left and the swept frequency generator and oscilloscope on the right. The resonant frequency is determined from the scope trace.

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FIGURE 36 - MICROWAVE SYSTEM

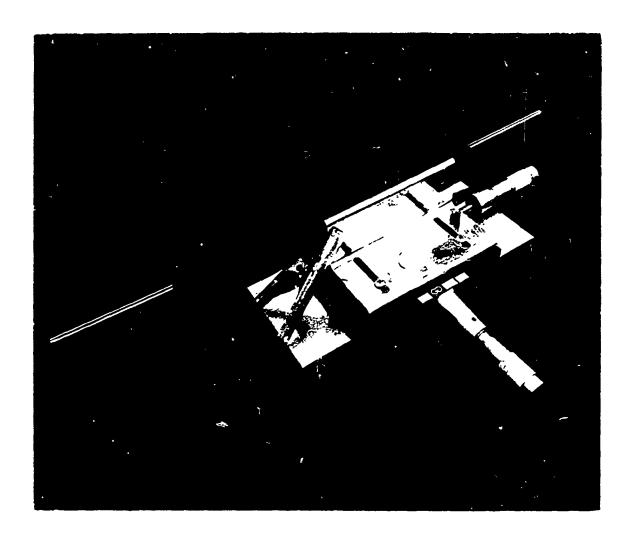
fixture had been changed to improved alignment of the specimens. Since this holding fixture changed between the two data points in the specimen history, the data cannot be directly compared and additional data is not available to verify the effect of the specimen holder on the read-out. Additional research beyond the scope of this investigation would be required.

Microwave resonance has shown promise since tests involving joint specimens with introduced voids yield significant changes in resonance frequency. The range for no voids was 53 to 74 Hz while the range for the same specimens after voids were introduced was 50 to 62. The above overlap would not be apparent if individual specimen readings were considered; i.e., 53 before to 50 after and 72 before to 62 after. This data demonstrated the capability of the microwave system. However, its use is limited since fine line measurements of actual bond quality is not comparable with the capability of current ultrasonic methods.

3.2.4 Visual Inspections: Bondline Measurement

The thickness of a bondline affects the quality or strength of a bonded joint. 'device was designed and built to optically measure the thickness of a bondline at the edge of a specimen (Figure 37). Initially, visible light was used to illuminate the bond joint. However, the interface between the adhesive and laminate was not well defined. After the bondline adhesive was found to fluoresce under ultraviolet light, the interface was easily defined for optical measurement (Figure 38). The inchnique utilized the micropositioner stage, ultraviolet light and a microscope as in Figure 39.

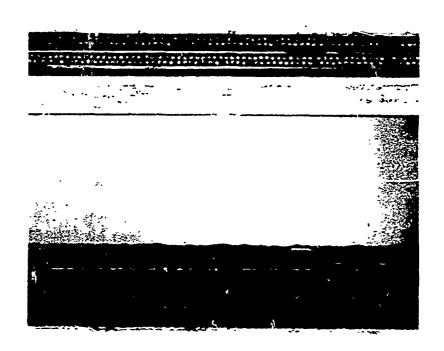
The bondline thickness measurement was accomplished by positioning a line in the eyepiece of the microscope on one side of the bondline, then turning the micrometer dial of the stage until the line moved to the opposite side of the bondline. The thickness was read directly from the dial with an accuracy of ± 0.0001 inch.



The micropositioner is mounted under the microscope and the bondline thickness reading is made directly from the micrometer dial. The dial is formed until a line in the microscope ejether moves on one side of the bondline to the other.

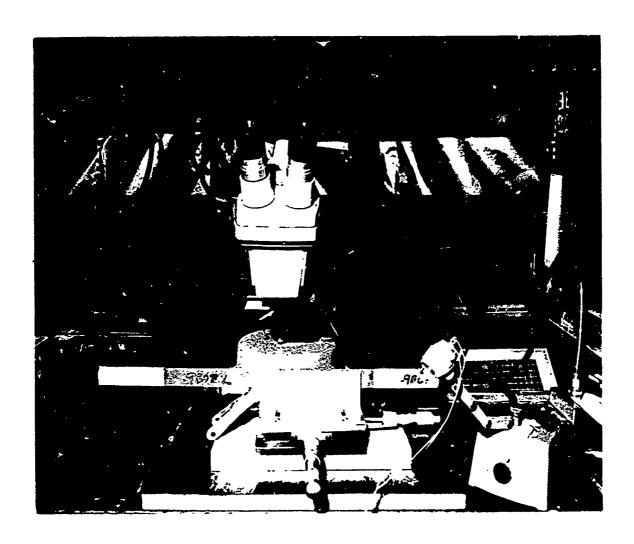
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FIGURE 37 - MICROPOSITIONER AND SPECIMEN



These are two typical configurations. One has a titanium splice plate and the other a boron splice plate. Bondline measurements are center of the nearest filament ply. The distance from the center of the filament ply to the edge of the specimen is subtracted from the reading.

FIGURE 38 - JOINT SPECIMENS SHOWING BONDLINES



The joint specimens are mounted on eage and illuminated with ultraviolet light. The bond-line fluoresces and becomes easily discernable. The bondline is viewed through the microscope.

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FIGURE 39 - BONDLINE MEASURING SYSTEM

Bondline measurements adjacent to boron adherends present a handicap, since the use of a peel ply on the boron laminate causes an irregular interface between the boron and the adhesive. Therefore, when boron adherends are involved, the measurement is taken to the centerline of the first ply of boron. To account for the thickness of laminate included in the measurement, 0.004" is subtracted from the recorded measurement. This correction includes the thickness of the half-ply included in the measurement and the thickness of the surface scrim and resin. When the adherend and splice are both composite, the measurement is taken from centerline to centerline of the first plies of the adherend and splice and then corrected by subtracting 0.008".

Specimens, representative of Configuration B and fabricated by the co-cured process, have also been inspected for bondline thickness by this procedure. During the curing and bonding process, the laminating resin and adhesive resin combine to such a degree that a finite bondline cannot be defined. Therefore, in joints of this type, the distance between the metal adherend and the centerline of the adjacant ply is measured. From this, an effective bondline is determined for use in analysis procedures and data correlation.

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3.2.5 NDE Data Analysis and Comparison

Utilization of ultrasonic, radiographic, microwave, and visual inspection methods permitted the establishment of the relative merits of each discipline. As a result the elimination of some disciplines may be possible with the incorporation of other disciplines.

As was stated previously the ultrasonics discipline presented what is believed to be the most useful data. The possibility of expansion or refinement of the technique into a more accurate qualitative evaluation system is most promising. At least two factors which must be resolved or investigated before the refined system could be established are:

- Rigid control of ultrasonic beam transmitted by the transducers; i.e.,
 energy level, frequency, etc.
- Development of more accurate calibration system for bondline joints
 with variance in cross-section; i.e., step joints.

Microwave investigation did not provide sufficient data to prove or disprove the merits of microwave testing. It is recommended that future analysis be made with this system using a finer control of the specimen vibration and that a device which measures the dielectric constant of the bond joint in-process be included in future investigations.

The capability of radiography was proven. However, it may not be necessary in future investigations of this sort. The catects detected were not of sufficient magnitude to warrant rejection by current standards. Therefore, it could be assumed that the joints can be sufficiently evaluated with the other disciplings.

As a result of this investigation the following recommendations for future work are made:

- o Radiography be limited to sampling only.
- o The dielectric comant device be utilized.
- o Ultrasonic testing be expanded to more definitive data.

All measurable variables which do not deteriorate the joint strength should be determined then compensated for in the non-destructive testing evaluation data. Once this is done effective joint quality data analysis can be accomplished. Microwave investigation did not provide sufficient data to prove or disprove the merits of microwave testing. It is recommended that future analysis be made with this system using a finer control of the specimen vibration and that a device which measures the dielectric constant of the bond joint in-process be included in future investigation.

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- o Radiography be limited to sampling only.
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3.3 MATERIAL ACQUISITION AND ASSESSMENT

During the course of the program, it was necessary to produce supporting material property data; although, to a great extent, reliance was placed upon composite materials data generated by the Lockheed-Georgia Company during conduct of contractual and in-house developmental programs. Data from related industry programs were also used, where applicable, to reduce the amount of required testing. Sufficient information exists on the composite materials and laminate orientations being used for this program to establish complete and dependable constant-life diagrams for the basic material. Snot check tests were performed on the composite materials used in this program to assure compatibility with available data.

The adherend materials used in this program fall into two general categories: metallic and composite. The basic uniaxial stress-strain data and fatigue properties (S-N curves) were required for all materials in order to provide properties for the analysis methods. These material properties were obtained from statistically significant data so as to remove these variables from the large number of other variables which will be evaluated during the program.

The stress-strain and basic fatigue behavior of the metallic materials were obtained from Military Handbook 5. Additional data, such as the thermal coefficient of expansion, Poisson's Ratio, and shear modules for the metallic materials, were obtained from Military Handbook 5 and Aerospace Structural Metals Handbook.

The basic lamina stress-strain and fatigue behavior of the boron composite materials were obtained primarily from the data being generated on Air Force Contract F33615-5257, "Structural Airframe Application of Advanced Composite Materials", at General Dynamics/Ft. Worth. Static and fatigue specimens were fabricated and tested to assure material quality and compatibility with the General Dynamics data.

Two other composite materials were included in the program evaluation but only to a very limited extent. These were graphite-epoxy and glass-epoxy.

Since these materials were included in consideration of the effects of variations in adherend materials and not to develop basic fatigue phenomena, as with the boron material, a high degree of confidence was not required for these materials. As a result, the level of activity associated with the graphite-epoxy and glass-epoxy materials are significantly less.

3.3.1 Acquisition of Tape Materials

Each of the composite material systems was purchased in the B-staged, prepreg tape form. Pertinent information related to materials and their acquisitions are given below.

Boron filaments were produced by Hamilton Standard and furnished to the prepreg company by the Air Force for use in connection with this program. The initial deliveries of tape material, through October 1970, were produced by Narmco Materials Division of Whittaker Corporation. Subsequent deliveries were made by Avco Systems Division, Avco Corporation. All boron tape material consisted of the same resin system and was supplied to the same material specification, FMS 2001A dated 21 April 1967. The delivery of boron tape material, quantities and identification are as shown below:

inder of the control

Feet of Tape Delivered	Receipt Date	Batch/Roll Nos.
1050	2 April 1970	381/74, 75, 76
1950	9 July 1970	392/89 thru 94
193	2 Oct 1970	385/6
1440	2 Oct 1970	408/35, 38, 39, 40
1450	13 Jan 1971	42/1, 2, 3, 4
600	20 Jan 1971	42/5, 6

The concluding material required for evaluation under the contract was a small quantity each of unidirectional fiberglass/epoxy and unidirectional graphite/epoxy. The total amount required was approximately 20 square feet of material. The fiberglass selected for this phase of the investigation was 3M Company's SP 1002 S glass (Batch L19, Roll W329) and the graphite material was Fiberit 1311B (Lot No. 1088, Roll No. 1).

3.3.2 Acceptance and Process Control Assessment

Material acceptance and in-process material evaluation specimens are tested in accordance with standard Lockheed-Georgia quality control specimen configurations and test procedures for composite materials. These methods are compatible with procedures used throughout the industry and include flexure and short beam shear evaluations of 15 ply unidirectional panels.

Fabrication details of all quality control and material acceptance panels and laminates for joints adherends are included in Appendix A, Table A1 - Composite Panel Identification, which provides a cross reference for these panels. In summary a listing of quality control panel numbers, material acceptance panel numbers, material batch numbers, and data usage is defined in Table 11.

3.3.2.1 Boron Epoxy - A summary of results obtained from both the acceptance and process control testing and the standards to which the results were compared are presented in Table III, on the basis of batch numbers. The data averages in each instance includes all the different specimens and panels which were evaluated from the specified batch. Other pertinent information related to the quality of the materials of each batch is discussed below.

Batch 381: The observed failures which occurred on the initial longitudinal flexure specimens, Nos. 54949-1 and -2, had a very unusual appearance in that, rather than the clean, regular breaks normally associated with longitudinal flexure tests, the specimens exhibit extensive delaminations extending from the break as much as one-fourth of the distance to the ends of the test specimen. For this reason an additional panel No. 56136, was fabricated and tested for 0° flexure strength and based on the results of these two panels batch 381 was considered acceptable. Batch 381 continued to exhibit good quality through the test results obtained subsequently.

TABLE II

BORON-EPOXY ACCEPTANCE AND CONTROL PANEL JUSTIFICATION

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Panel or Q.C. Number	Material Batch No.	Data Usage
54959	381	Material Acceptance
56136	381	Recheck Material Asceptance
56591	381	Q. C. Check on Material Verification
57836	381	Q. C. Check on Joint Panel
58392	381	Q.C. Check on Joint Panel
59038	392	Material Acceptance
59579	392	Material Acceptance
59813	381	Q. C. Check on Joint Panel
60365	381	Q.C. Check on Joint Panel
60581	392	Q. C. Check on Joint Panel
61039	392	Q.C. Check on Joint Panel
61198	392	Q. C. Check on Joint Panel
61588	392	Q. C. Check on Joint Panel
61873	408	Material Acceptance and Q. C. Check on Joint Panel
62844	38.5	Material Acceptance and Q. C. Check
63195	408	Q.C. Check on Joint Panel
63652	408	Q.C. Check on Joint Panel
64078	408	Q.C. Check on Joint Panel
64382	408	Q.C. Check on Joint Panel
64845	42	Material Acceptance
65418	42	Q. C. Check on Joint Panel
65745	42	Q.C. Check on Joint Panel
66858	42	Q. C. Check on Joint Panel
67326	408	Q.C. Check on Joint Panel
69552	43/3	Q. C. Check on Joint Panel
70085	43/6	Q. C. Check on Joint Panel
70085	45/11	Material Acceptance

TABLE WI BORON-EPOXY ACCEPTANCE AND QUALITY CONTROL DATA

Material Batch No.		Longitudinal Flexure	Transverse Flexure	Horizontal Shear	[0,00,0,0]	Tensile Coupon [0,0,90,0]	[0,±45,0] _s
Acceptance Standard		225	13.0	13.0	06		
381	Avg. Max. Min. Tests	247 268 237 23	14.3 16.2 17.7	14.6 15.3 18.6			
392	Avg. Max. Min. Tests	247 268 235 21	12.7 15.1 10.8 21	13.7 14.9 12.0 21			
385	Avg. Max. Min. Tests	259 268 247 3	12.8 13.6 3	14.0 14.1 3.8			
408	Avg. Max. Min. Tests	260 281 231 24	11.8 13.3 9.5 24	13.6 15.4 10.6	85.6 94.0 73.2	138 14 i 136	105 108 103
42	Avg. Max. Min. Tests	264 282 233 21	12.5 13.9 11.4	14.9 15.4 13.7	•)	,

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Material Batch No. 43	Avg. Min. Tests Avg.	Longitudinal Flexure 268 285 253 6	Flexure 13.0 14.7 11.3 6	Horizontal Shear 14.6 7.1 13.9 6	[0,90,0,00]	[0,0,90,0]	[0,±45,0]
	Max. Min. Tests	280 275 3	16.3 15.2 3	15.0 3.6			

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Batch 392: The initial results for Batch 392 were slightly below standard, panels 59038 and 59579, but tensile coupons having 0°/±45° fiber orientation and fabricated at the same time developed 100 ksi indicating material acceptable for joint fabrication. Subsequent Q.C. tests have shown improved values for this material with the exception of transversed flexure which frequently are below standard. Control specimens of all bonded joint panels were evaluated for static strength prior to specimens being fatigue tested, as a conditional requirement for accepting this batch of material

<u>Batch 385</u>: This batch consisted of a single roll of material and represented a partial shipment with Batch 408. The data representing the quality of this material also indicated a low transverse flexure strength.

Batch 408: This batch was the last lot of material supplied by Narmoo. Transverse flexure strengths continued to be below requirements although the horizontal shear and 0° flexure strengths were adequate for most specimens tested. The most severe variations observed for the program were detected in two panels of Batch 408 in which the transverse flexure values arranged 9.9 and 10.4 KSI. For the most part, however, the below-standard values have been near or above 12 KSI. Again, as a precaution all bonded joint panels were evaluated for static strength prior to evaluating specimens for fatigue capability. Specimens which exhibited low laminate properties were rejected and replacement specimen fabricated. Due to the very low initial results, No. 61873, additional tensile coupon tests were also performed on 0°/90° and 0°/±45° panels in conjunction with the standard Q. C. flexure specimens. Although the transverse flexure results were slightly below specification requirements (13 ksi), these laminates were used for joint specimen fabrication based on the acceptable results obtained from the tensile coupons.

Panels represented by Q.C. specimen numbers 64382 were rejected for use in the lap joint specimens. However, one panel was used for fabrication of the Configuration C specimens (Appendix C) based on acceptable tensile strength of these specimens.

Batch 42: Initial tests on Batch 42, the first batch supplied by Avco, show that it is approximately equal in quality to the material received from Narmoo. It should be

noted that the transverse flexure strength is marginal as it was for the last batch received from Narmoo, Batch 408.

<u>Batch 45</u>: The test results for these panels are, for the most part, consistent with previous determinations of a similar nature. An exception is noted for Batch 45, roll 11 which exhibited significantly higher transverse flexure and horizontal shear strengths than for other batches of material evaluated under this program.

3.3.2.2 Graphite Epoxy and Glass Epoxy - Due to the small amount of laminate material required for the fiberglass and graphite bonded joint specimens, the unidirectional 15-ply quality control laminates fabricated concurrent with the joint laminates also served for acceptance of the respective materials. Test results obtained from these specimens were acceptable, and were comparable to values obtained by other investigators. Tabulated results for these materials are listed in Table IV.

3.3.3 Material Properties Verification

To take advantage of the material properties data available from outside sources, it was first necessary to verify that the materials being received were of the same quality. A comparison was made between the verification tests recorded in Appendix B and data published in AFML-TR-69-101, Volumes IV and V, "Structural Airframe Application of Advanced Composite Materials". This was done with static and fatigue properties for (0,90,0,90)s and (0,±45,0)s laminates and the results are summarized in Appendix B1 for the individual static and fatigue property tests and in Figure 40 for the fatigue characteristics. The materials were judged to be sufficiently consistent for accepting the data base. The greatest variance is observed for the 0°/±45° fatigue testing at R = -1.0. This difference can be explained by the dissimilarity of cyclic rates during test, i.e., the General Dynamics data was developed at 1800 Hz and the Lockheed tests were made at 900 Hz. Another discrepancy is noted in the 0-90 tensile requirements but this difference was attributed to the fact that the requirement is set for sandwich beam tests which generally gives higher values than coupons.

TABLE IV

RESULTS OF CONTROL TESTING FOR
GRAPHITE-EPOXY AND GLASS-EPOXY LAMINATES

Specimen No.	Longitudinal Flexure Strength (KSI)	Horizontal Shear Strength (KSI)	
74169-1	187.5	14.4	
-2	170.3	14.0	F-1 1
-3	170.9	14.1	Fiberglass
Average	176.2	14.2	
74169-4	156.8	11.4	
- 5	162.0	11.3	Graphite
-6	155.3	11.1	
Average	158.0	11.3	

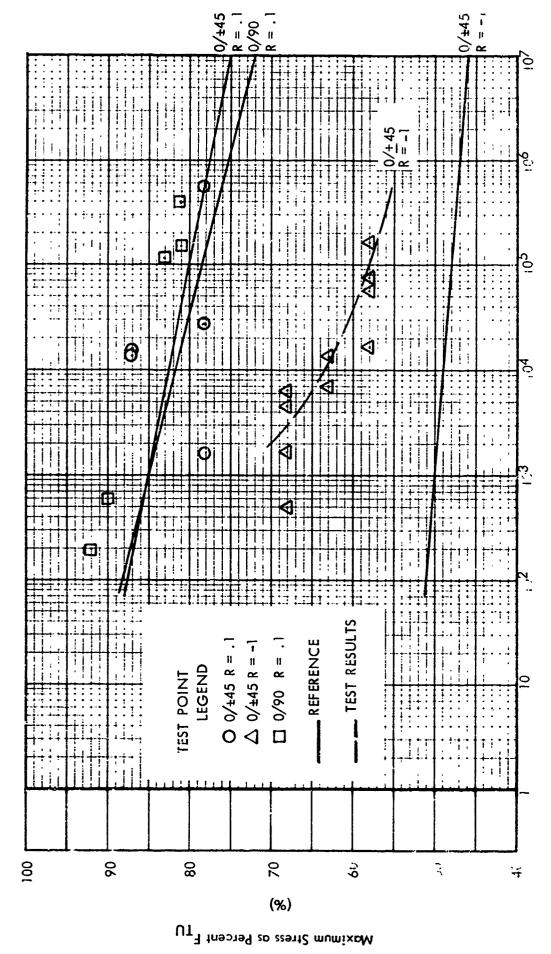


FIGURE 40 COMPARISON OF FATIGUE DATA FOR MATERIAL VERIFICATION

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SECTION IV TEST PROGRAM

4.1 GENERAL

The primary objectives of the test program were be develop improved methods for conducting fatigue design and testing of composite structural joints. Both bonded and mechanical joints were evaluated. Bonded and mechanical joint materials consisted of boron-epoxy, 7075-T6 aluminum, 6Al-4V titanium, graphite-epoxy and fiberglass-epoxy. The test specimens consisted of composite-to-composite and and composite-to-metal joints fabricated by both adhesive bonding and mechanical fastener techniques. A variety of joint designs were selected and were representative of joints that would be commonly used in aircraft structures. Specimen testing was accomplished in three main phases which were related to specimen size as follows.

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Phase I - Small scale laboratory joint specimens, one-inch wide. These specimens constituted the major portion of the test program.

Phase II - Medium scale joint specimens, two inches and three inches wide.

Phase III - Large scale joint specimens, ten inches wide. Only bonded joint specimens were tested in this phase of the test program.

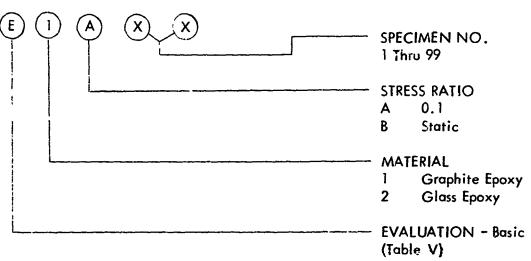
The complete test program is outlined in Tables V thru X Detailed test results and specimen parameters are included in tabulated form in Appendix B. Detail drawings of all specimens are included in Appendix C. All the unbalanced specimens were supported during static and fatigue testing in order to provide more consistent and representative test data.

TABLE V

ALTERNATE ADHEREND MATERIALS EVALUATION GRAPHITE EPOXY AND GLASS EPOXY COMPOSITES

COMPOSITE MATERIAL	JOINT CONFIGURATION	FATIGUE TESTS AT R = 0.1	STATIC CONTROLS
Graphite Epoxy	пДп	10	3
Glass Epoxy	"A"	11	3
	POTA I.S	21	6

SPECIMEN IDENTIFICATION EVALUATION - ALTERNATE ADHERENT MATERIALS



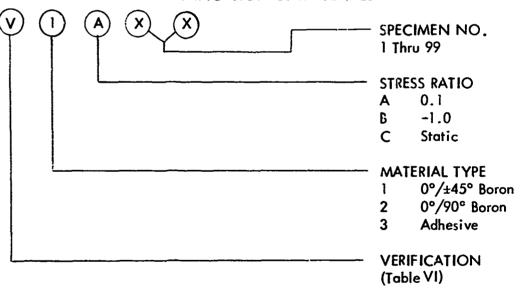
Specimen E1B01 identifies the number one static test specimen for basic evaluation of graphite epoxy.

TABLE VI

MATERIAL VERIFICATION AND CHECKOUT TESTS

MATERIA	L	FATIGUE	TESTS	STATIC CONTROLS
TYPE	SPECIMEN	R = 0.1	R = -1.0	TENSILE STRENGTH
0%±45° N 5505	Coupon	5	10	3
0°/90° N 5505	Coupon	5		3
Program Adhesives	Single Lap Joint	15		5
TOTA	AIS	25	10	. 11

SPECIMEN IDENTIFICATION VERIFICATION OF MATERIALS

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Specimen V1B04 identifies the number 4 fatigue specimen to be tested at a stress ratio of R = -1.0 for verification of material strength for a $0^{\circ}/\pm45^{\circ}$ boron laminate.

TABLE VII

BC! :DED JOINTS EVALUATION

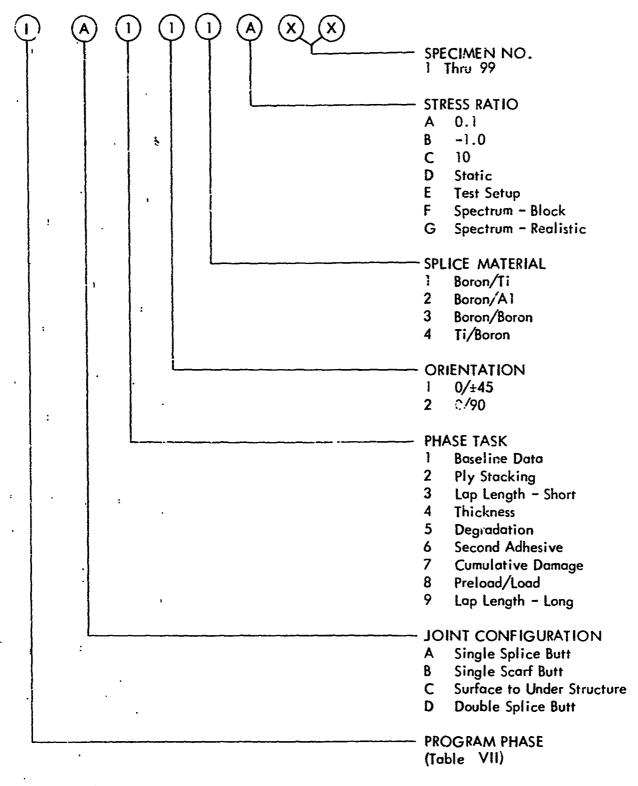
PHASE I - SMALL SCALE SPECIMENS

	r.E.S	(51.)	7	٥		2		13	٥,		က	₹		~	Į,							10%
	101ALS	FAT.	155	30		99		35	73		0	2		4	0			2	Ξ		14	375
	Ti/Baran . 1 (ST)		3														•					,
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	JOINT CONFIGURATION	LOADING STRESS RATIO	RASELINE DATA	0°/245°, Std.	2, 0°/90°, S:d.	PLY STACKING EFFECTS	1, ±45°/0°, 51d	LAP LENGTH EFFECTS	0°/±45°, Short Lap	2 0"/*45", Long Lap	THICKNESS EFFECTS	, 0°/±45°, Added Plies	2 0°/90°, Added Plies	DEGRADATION OF JOINT,	0.7+45°, 514	w	CUMULATIVE DAMAGE STUDY	0°/+45°, Std.	. Realistic Load Spectrum	2 Block Load Spectrum	PRELOAD/LOW CYCLE	0°, ±45°, Srd
								Q	1													

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TABLE VII (CONTINUED)

SPECIMEN IDENTIFICATION BONDED JOINTS - PHASE I



Specimen number IB121A08 identifies a specimen for Phase I with a single scarf butt configuration for generating base line data on $0^{\circ}/90^{\circ}$ specimen joined to titanium and tested at a stress ratio of R = +0.1. The specimen number within this set is number 8.

TABLE VIII

BONDED JOINTS EVALUATION PHASE II - MEDIUM SCALE SPECIMENS

JOINT CONFIGURATION		"A"			"B"			
ADHEREND COMBINATIONS	Вс	oron/1	i(Al*)	Bo	ron/I	li.	ТОТА	.LS
LOADING STRESS RATIO	0.1	10	(ST)	0.1	10	(ET)		
PROGRAM TASK		NUN	BER OF	SPECI	iens		FAT.	(ST)
BASELINE DATA	15*	5	10 **	10*	6	7 **	36	(17)
DEGRADATION OF JOINT PROPERTIES	10*						10	
IAP LENGTH EFFECTS 1. Short Lap 2. Long Lap	5	5	(6)	5		(3)	5 10	(3) (6)
CUMULATIVE DAMAGE EVALUATION FOR BLOCK SPECTRUM LOADING	[5]						5	
				9	POTALS	3	66	26

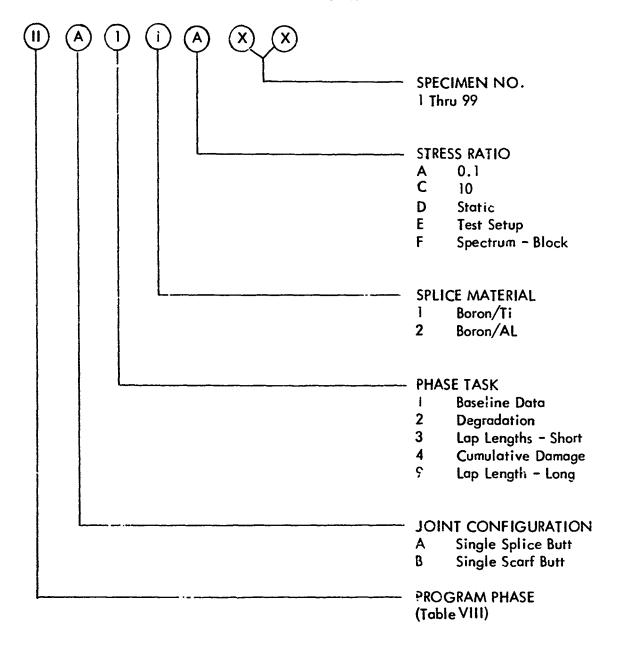
and the control of th

^{*} Five (5) specimens from each of the indicated groups are to have boron composite - aluminum adherends.

^{**} Three (3) specimens aluminum.

TABLE VIII (CONTINUED)

SPECIMEN IDENTIFICATION BONDED JOINTS - PHASE II



THE PROPERTY OF THE PROPERTY O

Specimen number IIA32C02 identifies a specimen for Phase II with a single splice butt configuration for evaluation of overlap length with aluminum splice adherend tested as a stress ratio of $R = \pm 10$. The specimen number within this set is number 2.

TABLE IX

BONDED JOINTS EVALUATION
PHASE III - LARGE SCALE SPECIMENS

JOINT TYPE		"A"	,			"B"		mor	14.10
· ADHERENDS		Boron	ı/Ti	(Al*)		Boron/Ti		101	'AIS
STRESS RATIO	0.1	-1.0	10	(ST)	0.1	-1.0	(ST)	FAT.	(ST.)
PROGRAM TASK		NUI	1BER	OF SPEC	IMENS				
AXIAL LOADING FOR LARGE JOINTS	2*	2*	1	(2*) 8 **	1	1	(3**)	7	13
COMPLEX LOAD EVALUATION FOR BLOCK SPECTRUM CYCLING	[1]				[1]			2	
						TOTALS		9	13

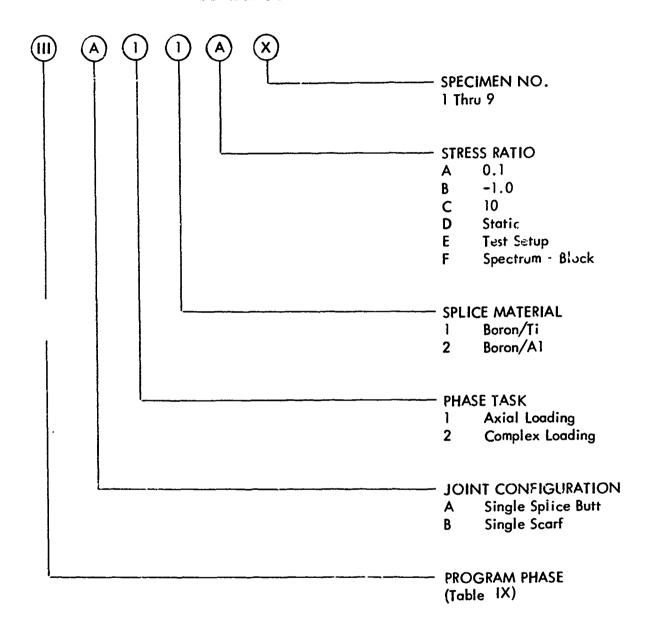
* One (1) specimen of each group indicated is to have boron composite - sluminum adherends.

** 1" wide static specimens.

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TABLE 1X (CONTINUED)

SPECIMEN IDENTIFICATION BONDED JOINTS - PHASE III



Specimen number IIIA11B2 identifies a specimen for Phase III with a single titanium splice plate but joint configuration for evaluation of axial loading a stress ratio of R = -1.0. The specimen number within this set is number 2.

TABLE X
MECHANICAL JOINTS EVALUATION
S WALL AND MEDIUM SCALE SPECIMENS

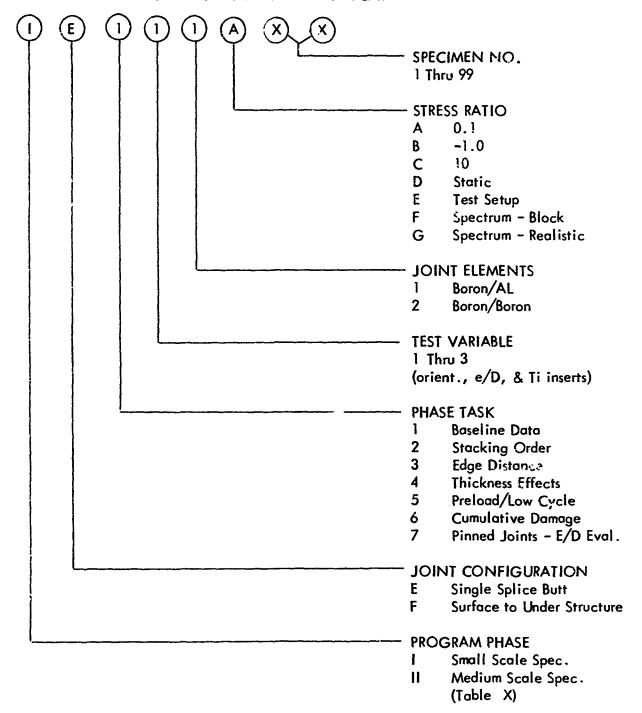
PROGRAM SECTION				SMA	PHASE 1 - SMALL SPECIMEN	VEN			MEDI	PHASE 11 - MEDIUM SPECIMEN	Z Z		
JOINT CONFIGURATION		ů					;-	; <u>u</u> .		Ē			
JOINT ELEMENTS		Boron/Ti	ij.	•	Boron	Boron Boron	900	ooron/A}		Boron/Ti		TOTALS	ALS
LOADING STRESS RATIO	. · . ·	-1.0	0	(15)	0.1	(51)	0.0	(\$1)	0.1	0	(51)	FAT	(ST.)
PROGRAM TASKS						NUMBER	NUMBER OF SPECIMENS	MENS					
BASELINE DATA i 0º//45º, Ti Inserts 2 0º, Ti Inserts	71	0	٣	(3)	2° 0	99	Ξ	(3)	9		9	% ⊆	17
STACKING CRDER - 0°/445°, 445° Buildup	'n	ď		ŝ								02	ო
EDGE DISTANCE 1. 0°/±45°, Ti Inserts 2. 0°/±45°, ±45° Buildup	v1 v2			ලිලි								w 0	වීම
THICKNESS EFFECTS 1. 0°/+15°, Ti Inserts 2. 0°/+45°, ±45° Buildup	vo vo			වල			Ŋ	69				٠ 3	36
PRELOAD/LOW CYCLE 0°/+45°, Ti Inserts	01											2	
CUMIJLATIVE DAMAGE 0°/+45°, Ti Inserts 1. Realistic Spectrum 2. Block Spectrum	27								ያ ያ			22	
PINNED JOINTS/EDGE DISTANCE EVALUATION i. (e/D), Ti Insens	'n			(5)								'n	ව
2 (c/D) ₂ , Ti Inserts	\$			3								S	<u>(6</u>
3. (e/D), 145° Buildup	\$			ල								'n	ල
									Sub Totals	otals		149	1,4

TOTALS

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TABLE X (CONTINUED)

SPECIMEN IDENTIFICATION MECHANICAL JOINTS - PHASE I & II



BENTA ONITO BENTALIAN SEPRETARIA DEL MINISTERIO DE LA PORTE DELA PORTE DEL LA PORTE DE LA PORTE DE LA PORTE DEL LA PORTE DE LA PORTE DE LA PORTE DEL LA PORTE DE LA PORTE DE LA PORTE DEL LA PORTE DE LA PORTE DE LA PORTE DE LA PORTE DEL LA PORTE

Specimen number IE311A03 identifies a specimen for Phase I with a single butt configuration for evaluation of fastener edge distance in a composite containing titanium skins joined to an aluminum splice plate. The specimen will be tested at a stress ratio of $R \approx \pm 0.1$ and is specimen number 3 within the set of specimens.

4.2 GENERAL TEST EQUIPMENT

4.2.1 Static Test Machines

Static tests were performed in either a Riehle or Baldwin universal testing machine. The Riehle had a load capacity of ±30,000 pounds and the Baldwin ±50,000 pounds. Teplin or Instron grips, attached to the machine with spherically seated adaptors, were used for the tensile tests. Self-aligning hydraulic grips were used for the compression tests. The testing machines were calibrated to appropriate ASTM Specifications using standards traceable to the National Bureau of Standards.

4.2.2 Fatigue Test Machines

The majority of fatigue tests at a stress ratio, R, of +0.10 were performed in Lockheed designed fatigue machines that operate on the resonant principal. A sketch of one of these machines is illustrated in Figure 41. Each machine has flat grips which will accept specimens up to three inches wide and up to 18 inches in length. One grip is attached to an electrical resistance type strain gage load transducer and the other grip to the test machine base. Signal from the transducer is directed to a dynamic load analyzer which includes calibrated potentiometers, a carrier amplifier, and an oscilloscope. In operation, the carrier amplitude is set by the calibrated potentiometers to a value proportional to the desired load. The carrier is then amplitude modulated by the transducer signal until a null is achieved on the carrier amplitude, and the oscilloscope is used to display the null condition. Maximum, minimum, and mean loads are monitored in this manner. Each machine system is statically calibrated to an accuracy of ±0.5 percent of load. A variety of transducers having different full-scale load capacities are available. However, the machines are limited to a maximum load of 15,000 pounds. Operating frequency range of the machines is 20 to 40 cycles per second and the operating frequency is established by the speed of the variable speed motor. The dynamic load at a given frequency is a function of the variable eccentric setting, variable mass of the machine, and position of the grips in the machine. Mean load is applied by a hydraulic

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FIGURE 41 - RESONANT FREQUENCY FATIGUE MACHINE

Therenamed and the control of the co

actuator on most of the machines, although some have a mechanical screw for this purpose. Each machine has an automatic cut-off system which stops the motor and cycle counter upon specimen failure.

Fatigue tests at stress ratios of R = -1.0 and R = +10.0 were performed in electro-hydraulic servo controlled testing machines, Mociels 301 and 303, manufactured by Mis System Corporation. These are direct force-type machines having full scale fatigue load capacities of ± 30 , 000 pounds and ± 100 , 000 pounds respectively. The lowest load range is 5,000 pounds on the Model 301 and 10,000 pounds on the Model 303. Each machine is equipped with MTS Alignomatic grips. Photographs of the testing machines are presented in Figure 42 and Figure 43. The electro-hydraulic servo controlled closed loop system provides infinite control of test frequency from approaching zero to limits of system response which is a function of hydraulic supply capacity, the servo valve, and test specimen compliance. Each MTS system was statically calibrated to an accuracy of $\pm 0.2\%$ of load range.

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4.2.3 Programming Equipment

The programming equipment used for the block loading and realistic spectrum testing was manufactured by MTS Systems Corporation. It can be used to control either of the MTS fatigue testing machines and a photograph of the Model 301 machine with the computerized programming equipment is shown in Figure 42 with the 30,000 pound MTS machine. The hardware consists of a PDP-8L computer, a model 33 ASR teletypewriter set, and an MTS 433.11 interface unit. The computer is prepared by means of an appropriate software program and test load information is input either manually on the teletype keyboard or by tape format on the tape reader. The digital format is then converted to a series of voltage commands by a digital to analogue converter located in the interface unit. Each command voltage is applied to the servo valve controller on the testing machine console and load is applied to the specimen. The load cell in the machine reacts the specimen load and a feedback voltage is created. This voltage is fed back to the interface unit where it is converted from an analogue signal to a digital value. The computer than screens and compares the digital command and feedback to verify that the specimen is subjected to the correct loadings. If any variations exist between command and feedback

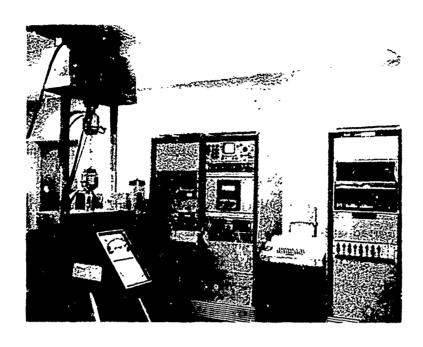


FIGURE 42 - MODEL 301 MTS MACHINE - 30,000 POUNDS

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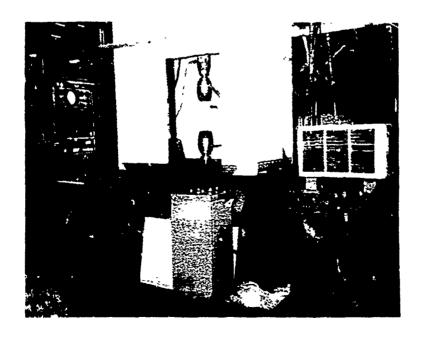


FIGURE 43 - MODEL 303 MTS MACHINE - 10,000 POUNDS

the program automatically halts. Accuracy of the programming system was found to be within ±0.5% of selected load range.

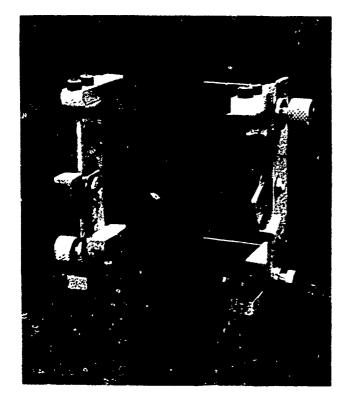
4.2.4 Instrumentation and Recording Equipment

Environmental and specimen temperatures were measured by copper-constantan thermo-couples connected to Honeywell multichannel strip-chart recorders. Since it was necessary to monitor temperatures at regular intervals throughout the duration of a test, each recorder was equipped with an automatic on/oif control device. This device was set to switch the recorder on for approximately thirty seconds at intervals ranging from 15 minutes to 4 hours depending upon test duration. Resistance strain gages, types FAE-03-12S13 and FAE-06N-12S13 were used on the strain survey specimens and strains were recorded on either a Baldwin strain indicator or a B&F Strain Data Acquisition System, Model SY156. Basic composite material modulus and joint stiffness were determined with an SR-4 frame extensometer equipped with strain gaged leaves as shown in Figure 44. A gage length of 2.0-inches was used for the bonded joints and a 3.25-inch gage length was used for the mechanically fastenered joints. Strain was recorded on the x-axis of an autographic recorder on the universal testing machine. During cumulative damage testing the specimen loads were monitored on a calibrated Clevite-Brush strip chart recorder, Mark 280.

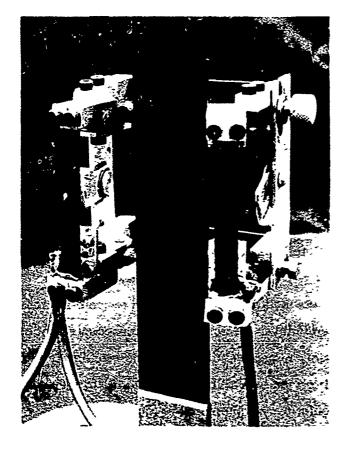
4.3 GENERAL TEST REQUIREMENTS AND TEST METHOD APPROACH

The critical dimensions of each specimen were measured and recorded along with its unique serialization. All tests were conducted at a room temperature of 72±5° Fahrenheit and any increase in specimen temperature was restricted to +10°F unless stated otherwise elsewhere in the report.

The fatigue tests were conducted at a variety of cyclic rates which were generally dependent upon stress level and stress ratio. However, the maximum frequency was limited to 1800 cycles per minute. Actual stress levels, stress ratios, and cyclic rates are given for each fatigue test in the test data tables, Appendix B.



Extensometer on Specimen



Strain Gage Leaves On Extensometer

FIGURE 44 - EXTENSOMETER SET-UP FOR MEASURING SPECIMEN STRAIN 107

4.4 MATERIAL VERIFICATION TESTS

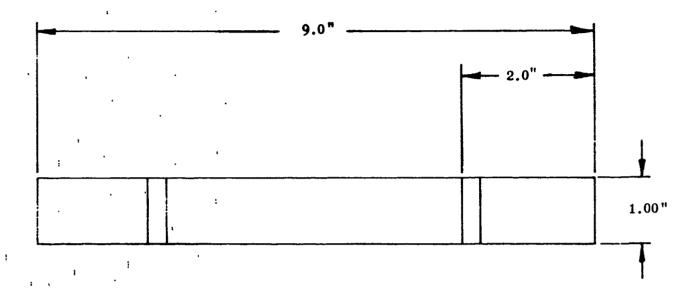
4.4.1 Specimen Configurations

The configuration of the static tensile and axial-load fatigue test specimen at R+0.1 is shown in Figure 45. The axial-load, R=-1.0 fatigue test specimen configuration is shown in Figure 46. Two tab materials were evaluated; half of the R=-1.0 fatigue specimens were fabricated with fiberglass tabs and the other half with aluminum tabs. The specimen configuration used for the adhesive evaluation tests is as shown in Dwg. No. 7226-13021A, but with titanium adherends and splice plate. Specimen identification information is given on Table VI.

4.4.2 Test Procedure and Results

Tests were conducted in accordance with Table VI, and the test data are reported in Appendix B, Table B1. The basic material static test specimens were instrumented with three strain gages as shown in Figure 45. A 2.0-inch gage-length extensometer was attached to each specimen and load was applied incrementally to failure. Strain gage output was recorded at each load increment and the extensometer output was plotted against load on an autographic recorder. Good correlation was obtained between the measured results of the two systems as illustrated in the response curve of Figures 47 and 48.

Constant amplitude axial-load, $R = \pm 0.10$ fatigue tests were conducted in Lockheed designed resonant testing machines, Figure 41. One thermocouple was bonded to each specimen at the center of its length and was used to monitor specimen temperature for the duration of the test. Ambient remperature was measured by a thermocouple bonded to a piece of boron-epoxy composite material, suspended from the testing machine in the proximity of the test specimen. Typical fatigue failures for the $R = \pm 0.10$ fatigue specimens with $0^{\circ}/\pm 45$ and $0^{\circ}/90$ fiber orientations are presented in Figure 49.



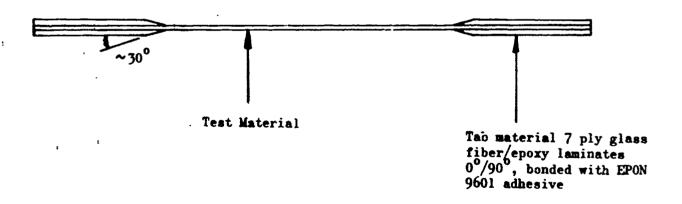


FIGURE 45 - AXIAL-LOAD FATIGUE TEST SPECIMEN CONFIGURATION R = +0.10

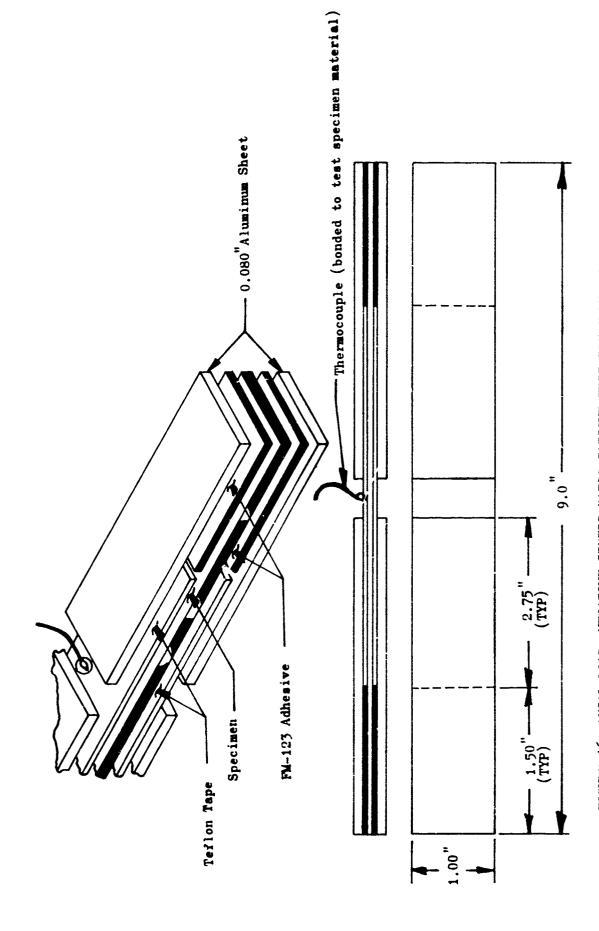
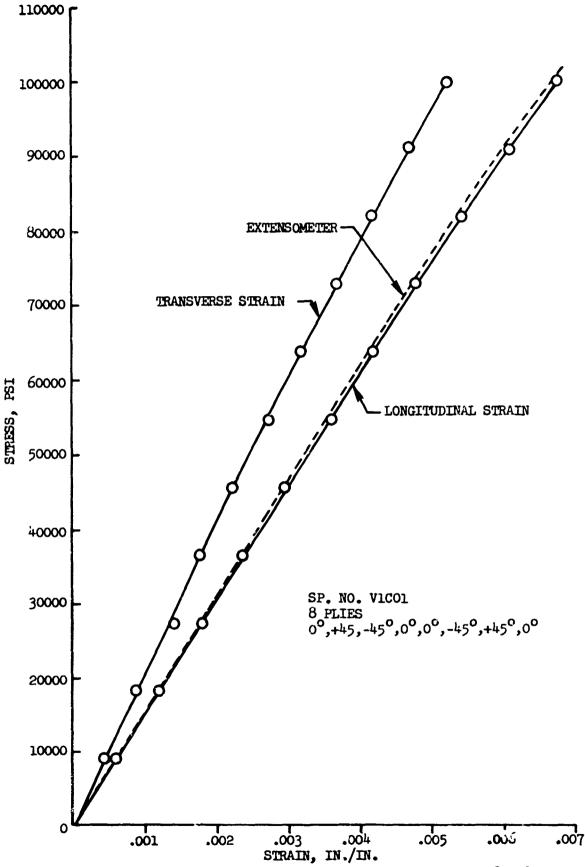


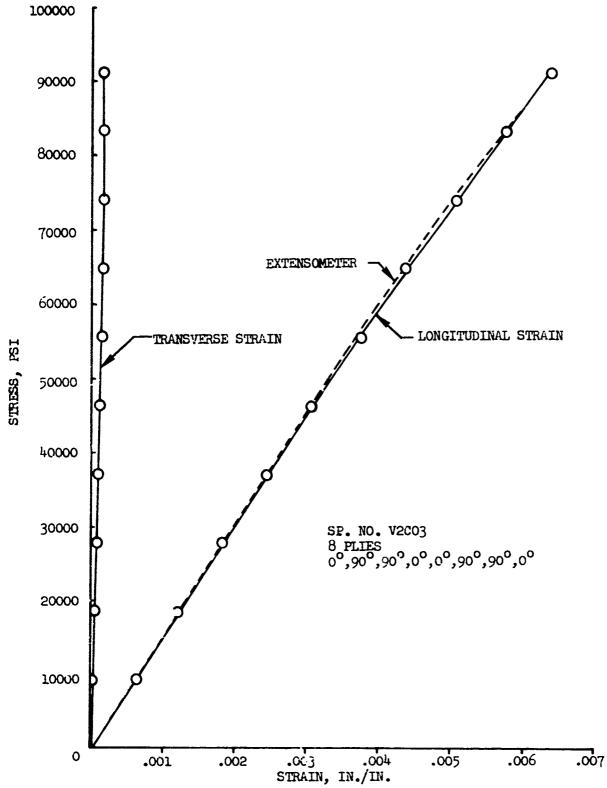
FIGURE 46- AXIAL-LOAD, NEGATIVE STRESS RATIO FATIGUE TEST SPECIMEN CONFIGURATION

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FIGURE 47 STRESS-STRAIN RELATIONSHIP TENSILE COUPON 00+450



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FIGURE 48 STRESS-STRAIN RELATIONSHIP TENSILE COUPON - 0°/90°

Constant amplitude axial-load, R = -1.0 fatigue tests were conducted in an MTS electrohydraulic servo controlled closed loop testing system. One thermocouple was bonded to each test specimen at the center of its length as shown in Figure 46. Two aluminum support plates, approximately 5 inches long X 2 inches wide X 0.25-inch thick, were attached to the specimen, one on each side and held together by six 0.25-inch diameter fasteners. The fastener nuts were tightened to provide adequate lateral support for compressive loading without creating excessive friction between the plates and specimen during axial loading. Typical failures for the R = -1.0 fatigue specimens with aluminum tabs and fiberglass tabs are shown in Figure 50. Due to difficulties encountered with an excessive temperature rise in the R = -1.0 specimens, the tests were repeated and the problem was solved by restricting the test cyclic frequency to 180 cycles per minute. All previous test results had indicated that the aluminum-tabbed specimens gave comparable fatigue data to that of the fiberglass-tabbed specimens and the repeated tests confirmed this (see Since the aluminum tabs were more uniform in thickness and easier to Figure 51. use than the fiberglass tabs, it was felt that it would be advantageous to use aluminum tabs on all future joint specimens.

Prior to conducting the adhesive evaluation tests some experimental testing was carried out to determine a satisfactory support plate system. A quantity of test specimens with titanium splice plates bonded to titanium adherends were fabricated. Initially, support plates were attached to the adherends spanning the splice plate but not offering any support to the splice plate. This method was considered non-representative since the splice plate was still free to deflect a substantial amount when loaded. Using the same basic support plates, spacers were placed in the gap between the spliced area on both faces. These spacers were 1.0-inch wide and of sufficient thickness to completely fill the gap without providing an interference fit. Testing indicated that this method was successful but it was felt that, since the joint was only supported over the center 1.0 inch of its total overlap length of 1.5 inches, to offer similar support to a joint of different overlap length the spacer length would also have to be different and therefore complicate the testing procedures. Finally it was decided that the joint should be supported across the whole overlap area but still allowed to deflect a limited amount.

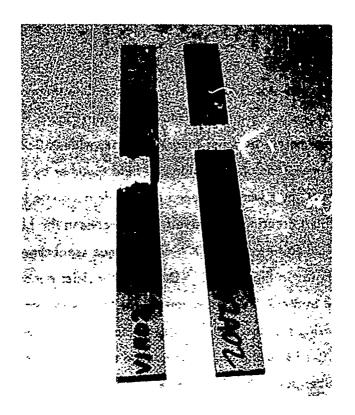


FIGURE 49 - TYPICAL FAILURE, AXIAL FATIGUE R = +0.10

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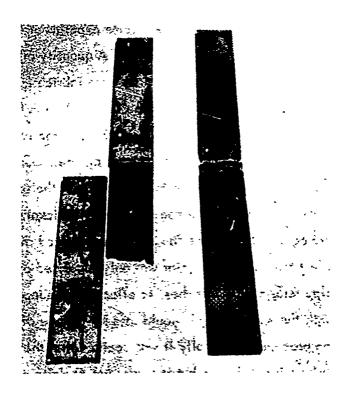


FIGURE 50 - TYPICAL FAILURE, AXIAL FAFIGUE R = -1.0

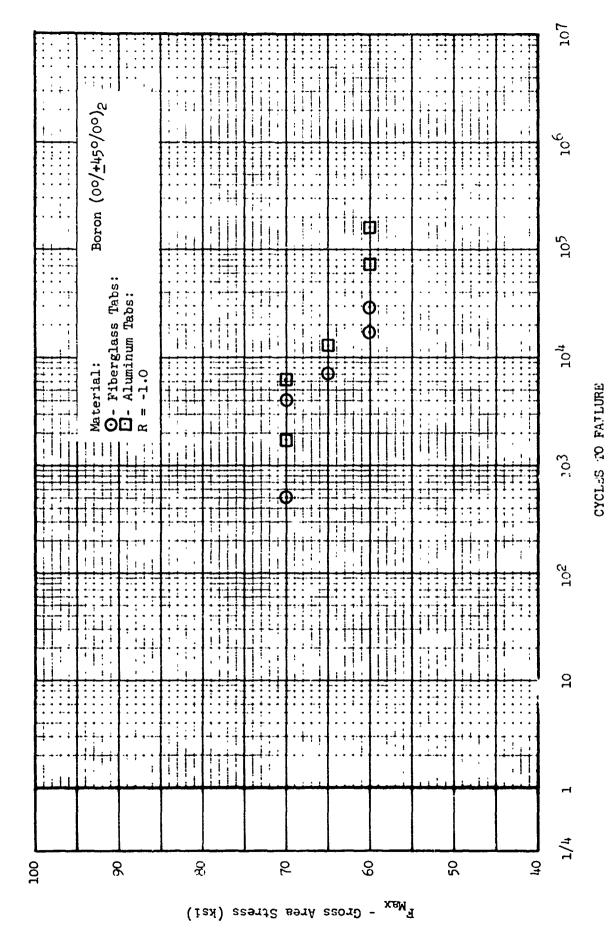


FIGURE 31 - MATERIAL VERIFI JATION FATIGUE TEST

mineral progression was a comparable to the comparable of the comp

This condition was believed to be representative of a typical joint between skins bonded to a honeycomb core or supported by a substructural member. The system that satisfied these requirements was successfully checked out on additional specimens fabricated with boron composite adherends and at various stress levels and stress ratios (see Table B2, Appendix B). Details of the support system that was adopted for Configuration A bonded joint test specimens are given in the sketch, Figure 52. The gap on each side of the joint was restricted to 0.003 inch (one thickness of Teflon tape) since this provided adequate and representative support to the joint without creating any significant frictional resistance when loaded. One of the experimental joint speciments with support plates attached and mounted in a resonant fatigue machine is shown in Figure 53.

The static and fatigue adhesive evaluation tests were conducted using the support plate system described above. Typical static and fatigue failure surfaces are shown in Figures 54 and 55. The Epon 9601 adhesive exhibited high ultimate shear strength and the S-P: curve, shown in Figure 56 indicates that the fatigue characteristics were also acceptable.

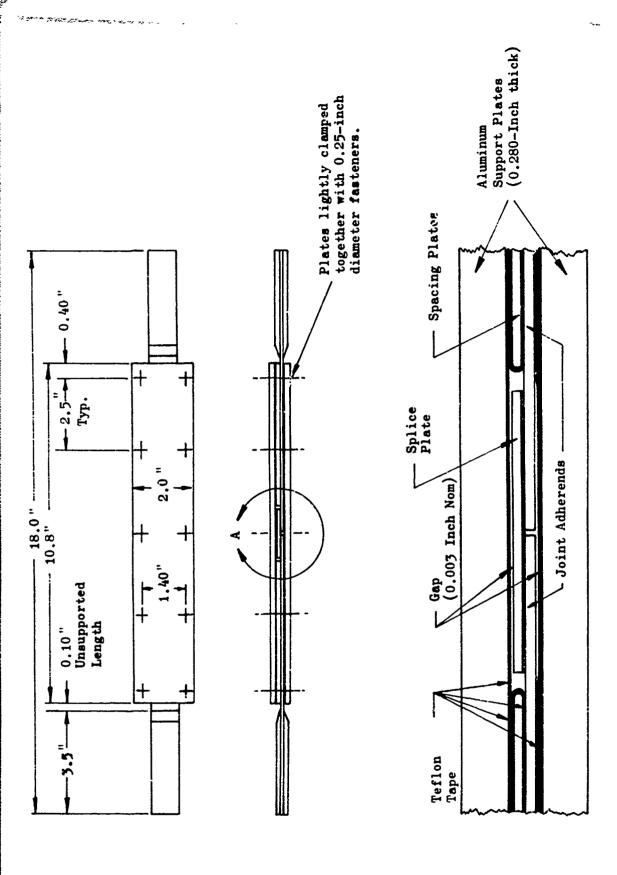
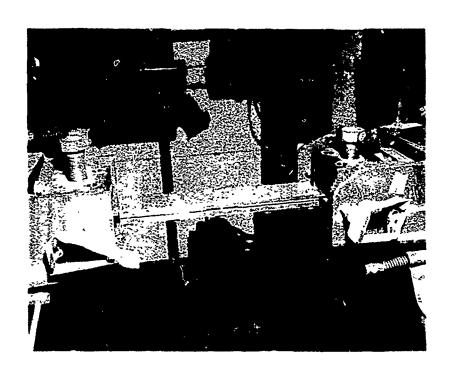


FIGURE 52 SUPPORT SYSTEM FOR TYPE "A" JOINT SPECIMENS

VIEW "A"

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FIGURE 53 - TEST SPECIMENS WITH SUPPORT PLATES



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FIGURE 54 - TYPICAL STATIC FAILURE SURFACE TITANIUM TO TITANIUM (V3CO3)

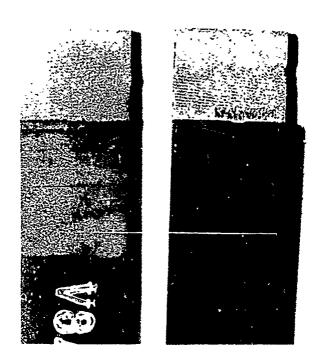


FIGURE 55 - TYPICAL FATIGUE FAILURE SURFACE TITANIUM TO TITANIUM (V3A12)

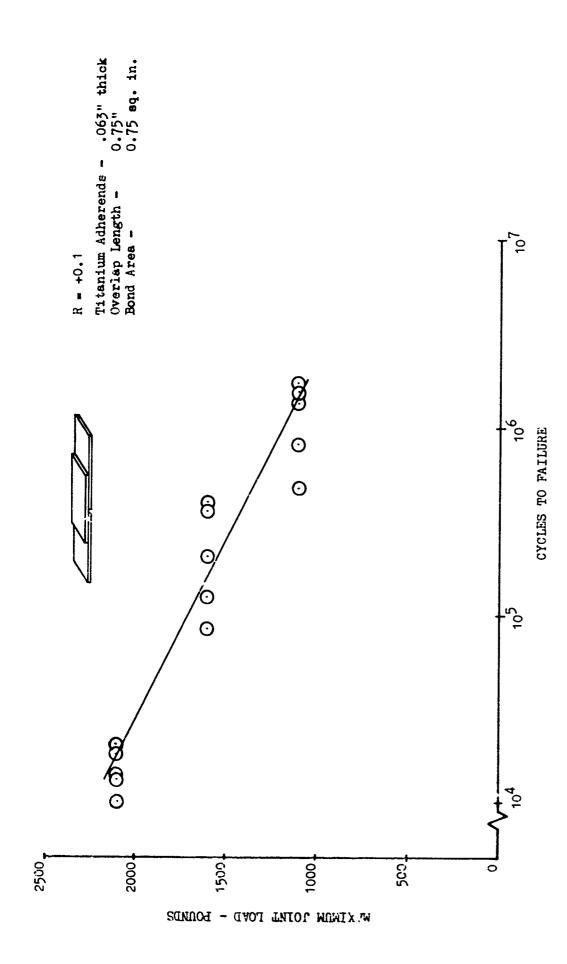


FIGURE 56 S-N CURVE FOR SINGLE SPLICE BUTT JOINT CONFIGURATION A - EPON 9601 ADHESIVE

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4.5 BONDED JOINT TESTS - CONFIGURATION A - SINGLE SPLICE BUTT JOINT

4.5.1 Specimen Configuration

The Phase I, Configuration A specimen details are given in Dwg. No. 7226-1302IA, Appendix C. The Phase II and Phase III specimens were fabricated to the same drawing but the width dimension was increased to 3.0 and 10.0 inches respectively. Specimen identification information is given on Tables VII, VIII, and IX.

4.5.2 Test Procedure and Results - Phase I

Tests were conducted in accordance with Table VII, and the test data are reported in Appendix B, Tables B3 thru B9.

Tests were also conducted on alternate adherend materials in accordance with Table 1 and the test data were reported in Appendix B, Table B17. The static tensile test specimens were supported with the modified support plates shown in Figure 57. The modification to the plates was necessary to alloy a 2.0-inch gage-length extensometer to be attached to the edges of the specimen. A typical static tensile test set-up with extensometer attached is shown in Figure 58. A minor problem was caused by the buckling of the lateral support plates during the static compression testing of the long lap joint specimens. The buckling was a result of the higher loads required to fail this type of specimen combined with the effect of the reduced stiffness of the plates due to the cut out at the center. Increased stiffness to the support plates was provided by attaching a "T" section stiffner along the length of and on one side of the support plates as shown in Figure, 59 and Figure 60. A thermocouple was bonded to each specimen and was located on the adherend adjacent to the edge of the splice plate. The fatigue tests were conducted in the fatigue machines described earlier and with regular support plates. Figures 61, 62 and 63 illustrate the different failure modes obtained with the Configuration A baseline specimens when subjected to the different fatigue stress ratios of R = +0.10, R = -1.0, and R = +10.0. Failure modes associated with the ply stacking variable, surface ply at 45° to load axis, for Configuration A boron-to-titanium and

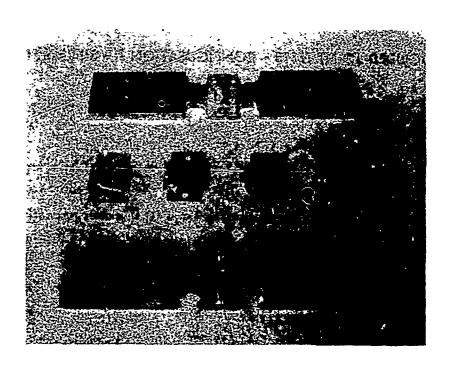


FIGURE 57 MODIFIED SUPPORT FIXTURE

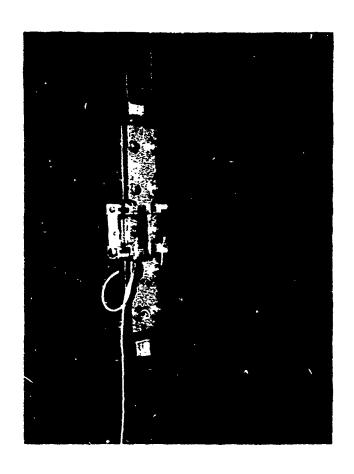


FIGURE 58 STATIC TENSILE TEST WITH EXTENSOMETER

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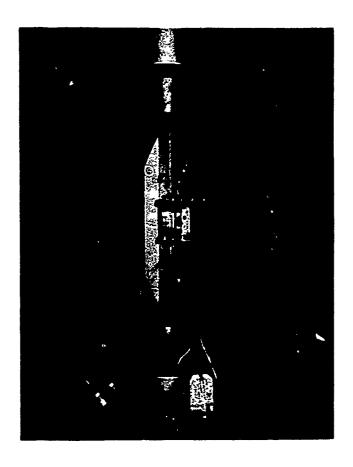


FIGURE 59
SIDE VIEW OF MODIFIED SUPPORT PLATE

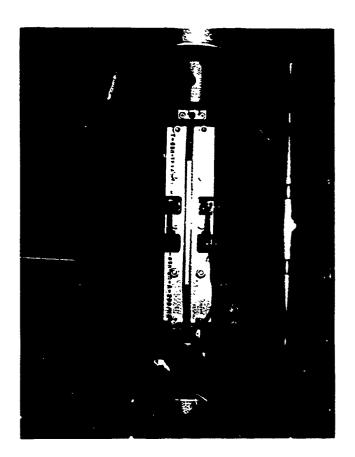


FIGURE 60 FRONT VIEW OF MODIFIED SUPPORT PLATE

and the state of t



-A04 shows unusual splice plate failure
-A10 shows typical failure adjacent to surface ply

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FIGURE 61 - CONFIGURATION A, BORON TITANIUM BASELINE SPECIMEN STRESS RATIO $R = \pm 0.1$

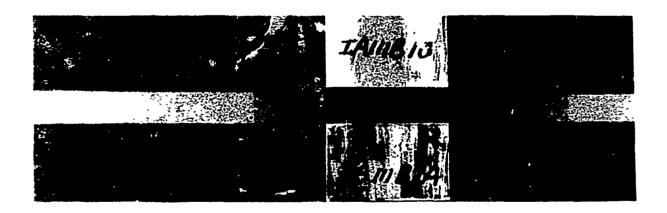
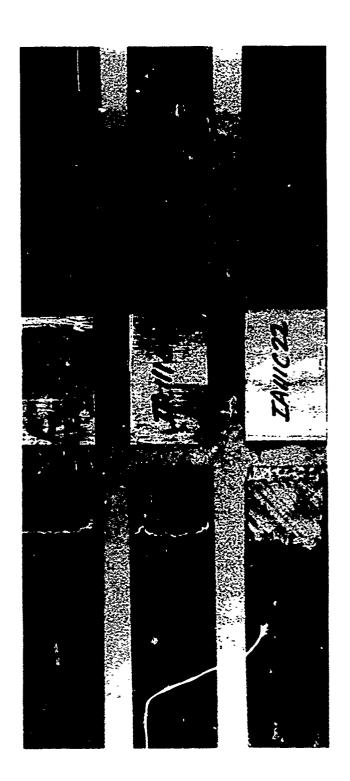


FIGURE 62 - CONFIGURATION A, BORON/TITANIUM BASELINE SPECIMEN STRESS RATIO R = -1.0 TYPICAL FAILURES



-COl Failure adjacent to surface ply plus some end damage -ClO Failure adjacent to surface ply and no secondary damage -C22 Failure between surface ply and $45^{\rm O}$ ply

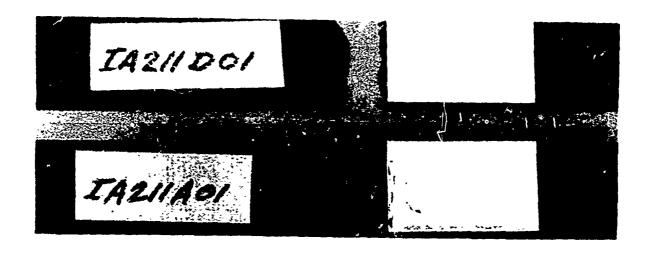
FIGURE 63 - CONFIGURATION A, BORON/TITANIUM BASELINE SPECIMEN STRESS RATIO R = +10.0. TYPICAL FAILURES

mender of the contraction of the

boron-to-boron joints are shown in Figures 64 and 65. In addition to the degradation specimens, all other types of Configuration A fatigue specimens that had not been failed during testing were statically tested to failure. Joint deflection was recorded for each specimen to determine possible degradation in joint stiffness due to fatigue loading. The low cycle tests were conducted in an MTS electrohydraulic servo controlled closed loop system at a frequency of 5 cycles per second. An attempt was made to obtain fatigue lives of between 2500 and 5000 cycles, however this proved to be difficult and the test data produced a scatter band of about two decades.

Good static shear strengths were obtained for the joints loaded in tension with values ranging from 3600 psi to 5700 psi and with an average value of 4600 psi. This spread in static strength is reasonable when comparing results from specimens representing several different batches of material bonding cycles and L/t ratios. Compressive shear strength values varied between 5500 psi and 6300 psi. Additional baseline data tests were conducted at a stress ratio of R = -1.0 and at a cyclic rate of one cycle per second to determine the influence of cyclic rate on fatique life. These yielded the same results as tests conducted at 900 to 1800 cycles per minute, indicating that cyclic rate is not a prime factor unless it causes the specimen to overheat. Joint stiffness curves for tensile and compressive static loading before and after fatigue cycling are given in Figures thru 69. 66 Boron-to-boron joints with the second adhesive, Metlbond 329, were evaluated and the results are reported in Appendix B, Table B4. Since static tests on boron-to-titanium joints with this same adhesive yielded low static strength values, and initial fatigue test results were also low (all specimens failed at the adhesive-titanium interface) testing on the remainder of the specimens was suspended because these specimens did not evaluate the adhesive to composite joint.

For the prelocal evaluation tests, static tensile preloads were determined by taking 75 percent, 85 percent, and 90 percent of a predetermined static value established as the design ultimate shear atress. This stress was 4000 psi and was determined by deducting one standard deviation from the mean value of all the static tensile ultimate values obtained for the standard boron/titanium, Configuration A joint specimens. Joint deflection was recorded during the static preload to provide additional information. Fatigue



- -DO1 Typical static tensile failure in boron -A01 Typical R = 40.1 fatigue failure between surface 450 ply and second 0° ply
- FIGURE 64 CONFIGURATION A, BORON/TITANIUM PLY STACKING SPECIMEN



- -DO2 Typical static tensile shear failure between surface 45° ply and second 00 ply -A06 Typical R = +0.1 fatigue failure (same as DO2)

FIGURE 65 - CONFIGURATION A, BORON/BORON PLY STACKING SPECIMEN

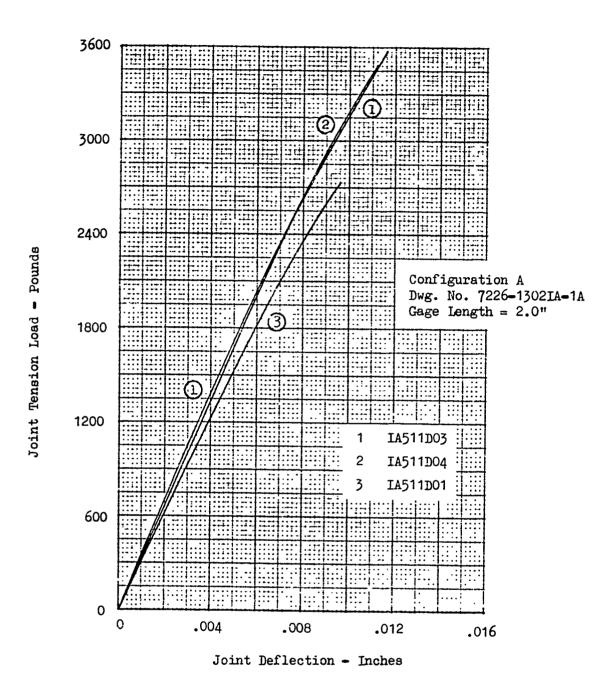
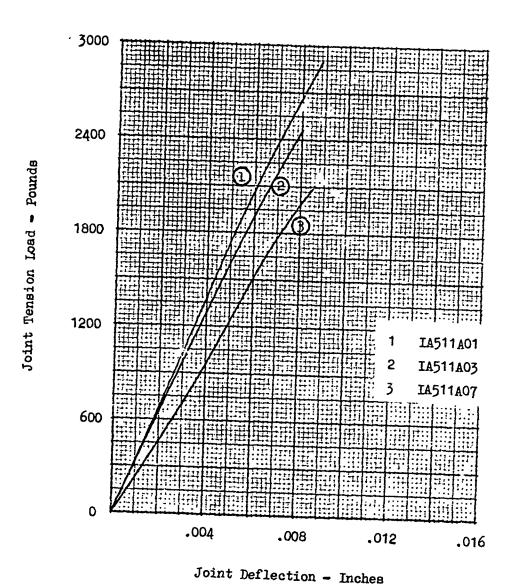


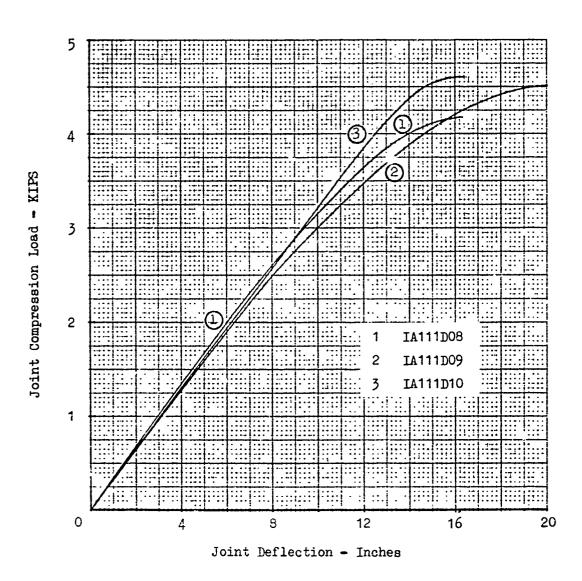
FIGURE 66 JOINT STIFFNESS - STATIC TENSILE TESTS



Configuration A

Dwg. No. 7226-1302IA-1A Gage Length = 2.0"

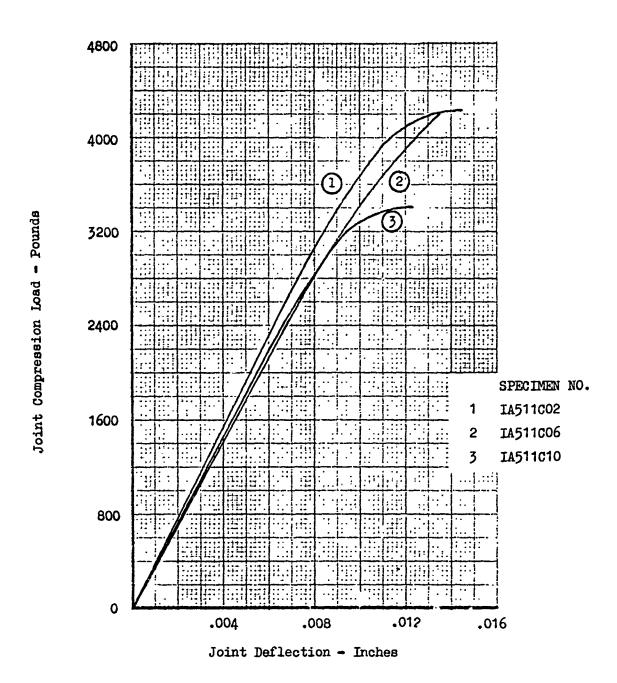
FIGURE 67 JOINT STIFFNESS - AFTER FATIGUE CYCLING



Configuration A
Dwg. No. 7226-1302IA-1A
Gage Length = 2.0"

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FIGURE 68 JOINT STIFFNESS - STATIC COMPRESSION TEST



Configuration A Stress Ratio R = +10.0 Dwg. No. 7226-1302IA-1A Max. Stress 2700 psi Gage Length = 2.0" No. of Cycles 5000

FIGURE 69 JOINT STIFFNESS - AFTER FATIGUE CYCLING

tests were conducted at a stress ratio of $R=\pm0.1$ and at a stress level of 1400 psi. Results, Appendix $\tilde{\nu}$ Table B3, indicate that the preload does not significantly affect the fatigue life of the joints.

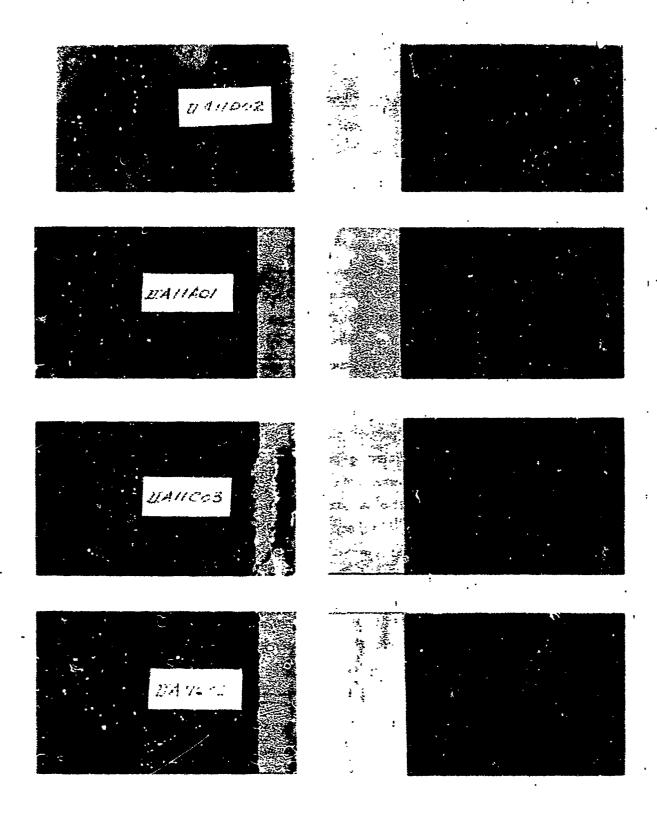
The graphite-epoxy and glass-epoxy alternate adherend material evaluation tests were conducted in the same manner as the baseline data boron-epoxy tests. The fatigue tests were performed at a stress ratio of R = +0.10 and at stress levels that were comparable to those used for the boron-epoxy tests. The results are presented in Appendix B Table B3. S-N curves for all data generated are presented in . If of this report. Analysis and comparative studies for all specimen variables are also included in Volume III.

4.5.3 Test Procedure and Results - Phase II

Tests were conducted in accordance with Table IX and the test data are reported in Appendix B, Table IIB1.

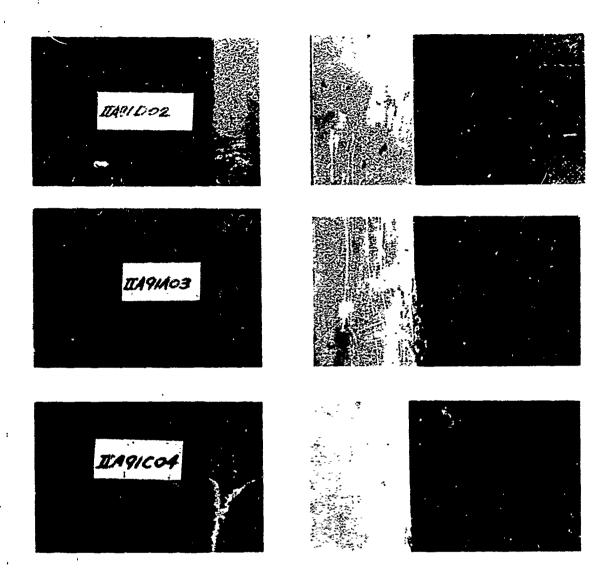
The three-inch wide, Configuration A bonded joints were tested using methods similar to those adopted for the appropriate Phase I one-inch wide specimens. Except for the extra width, the support plates were identical to those used on the one-inch wide specimens and the same clearance of approximately 0.003 inch was maintained in the area around the splice plate. The increased width made it necessary to modify the extensometer frame and this was accomplished by utilizing longer connecting straps and lorger knife-edged attachments. Some difficulty was encountered with tab failure: occurring during the testing of the static specimens. However, satisfactory joint snear strength values were obtained by removing the tab ends and gripping the laminate with a piece of coarse emergy cloth between the laminate and grip surfaces. For this method of gripping, the support planes had to be shortened by two inches at each end in order to expose sufficient gripping area. Typical failure modes for the 3.0-inch wide Configuration A specimens are presented in Figures 70, 71, and 72. Static tests resulted in either partial or complete tensile failure of the boron while the R = +0.1 fatigue tests resulted in shear failure adjacent to the first ply and partial failure of the surface plies. In analyzing the data obtained from these 3.0 inch wide baseline specimens, as compared with those data generated for so lifer 1.0-inch wide baseline specimens, a trend is indicated in that there is a loss in joint static shear strength and fatigue life with increase in specimen width, holding overlap length constant. This trend was later extended to the 10-inch width. A similar relationship holds true for the lap length effects data, and the boron-toaluminum baseline data.

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-D02 Typical tensile faiture in the boron laminate
-A01 Typical R = +0.1 fatigue shear failure adjacent to first ply
-C03 R = >10.0 fatigue faiture with partial faiture of surface plies
-C05 R = +10.0 fatigue shear failure adjacent to first ply

FIGURE 70 - CONFIGURATION A - THREE INCHES WIDE BORON/TITANIUM, BASELINE SPECIMENS

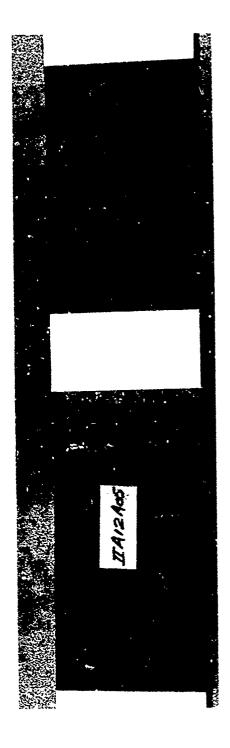


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opselen näätiän mennempiisaiskin joka kean tridivisiniaa ekriödrinapiikainteiniaan kennen arasin 1805 perkinia

- -DQ2 Typical static failure in boron laminate combined
- with shear adjacent to surface ply
 -A03 Typical R = +0.1 fatigue shear failure adjacent to first ply
- -CO4 Typical R = +10.0 fatigue failure with partial failure of surface plies

FIGURE 71 - CONFIGURATION A - THREE INCHES WIDE BORON/TITANIUM, LONG LAP LENGTH



-AO5 typical R = + O.1 fatigue shear failure adjacent to the first ply of boron

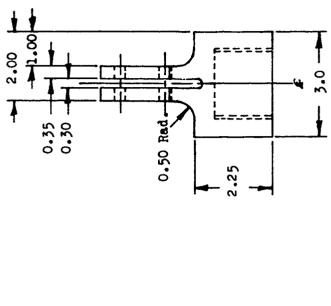
FIGURE 72 - CONFIGURATION A - THREE INCHES WIDE BORON/ALUMINUM BASELINE SPECIMEN

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4.5.4 Test Procedure and Results - Phase III

Tests were conducted in accordance with Table IX and the test data were reported in Appendix B, Tables IIIBI. One-inch wide specimens were cut from the edge of the same panel as the 10.0-inch wide specimens and were used for evaluating the static shear strength of the bond. These tests were conducted in the same manner as the Phase I, Configuration A specimens.

The test procedures used for the ten-inch wide Phase III Configuration A joint specimens were similar to those used for the Phase I and Phase II specimens except that the load was introduced through bolted end fittings rather than hydraulic grips. All tests were carried out in an MTS testing machine equipped with steel end fittings, fabricated to the configuration shown in Figure 73. In order to ensure correct specimen alignment in the fittings, a drilling template was used to locate the holes in the specimen ends. Eleven-inch wide lateral support plates were used and a clearance of 0.003 inch was maintained in the joint "T" section stiffeners were fastened to the plates to provide the additional support required for the fatigue test at R = +10.0. Two thermocatoles were bonded to each speciment, one at the edge and the other at the center of the width. A photograph of an R = +0.1 fatigue test specimen mounted in an MTS testing machine is shown in Figure 74. Typical failure surfaces of the static control specimens are shown in Figures 75 and 76. Photographs of four 10.0-inch wide specimens after fatigue testing are also shown in Figures thru 80. Two specimens had complete failure across the 10.0-inch width, but the other two specimens had a narrow bond, approximately 2.0 inches along the edge, that did not fail. Generally, the fatigue failure modes were shear adjacent to the surface ply, and this mode appeared to initiate at the center of the joint width and move outward as illustrated in Figures 77 and 78. This theory is strengthened by the fact that the specimens, shown in Figures 79 and 80, did not fail over the complete bond width. The results of the 10.0-inch wide tests indicate that the fatigue capability is further reduced when the specimen width is increased from 3.0 inches to 10.0 inches.



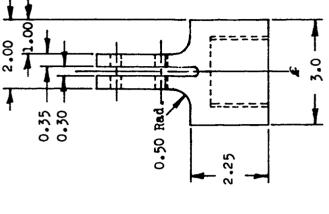
5.00

2.00

1.30

(Typ.)

10.0



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END FITTING FOR PHASE III, 10.0-INCH WIDE SPECIMEN 73 . FIGURE

2-12 Threaded Hole, 1.50-inch Deep

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10 Holes, 0.25-inch Diameter

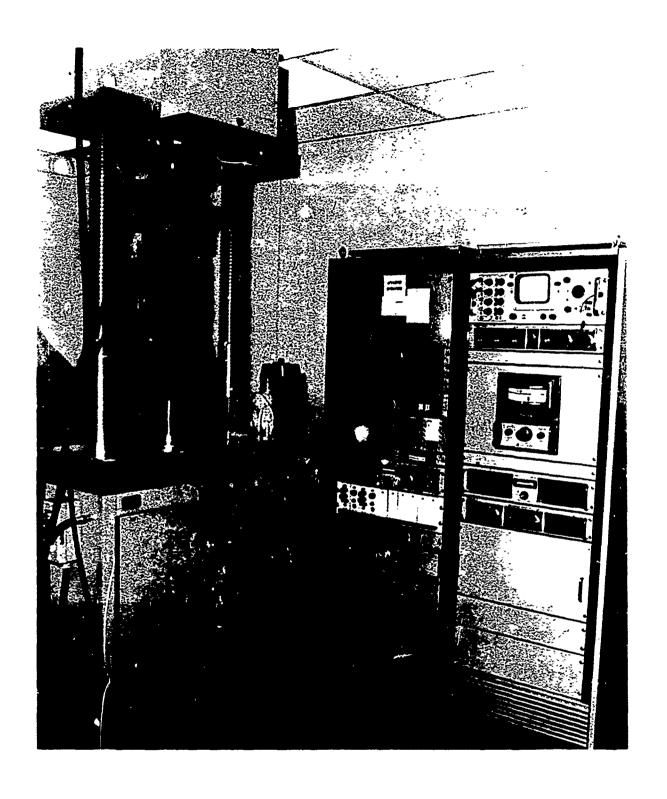


FIGURE 74 - TEST SET-UP FOR TEN-INCH WIDE CONFIGURATION A SPECIMEN

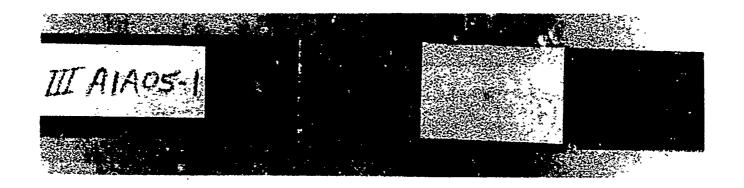
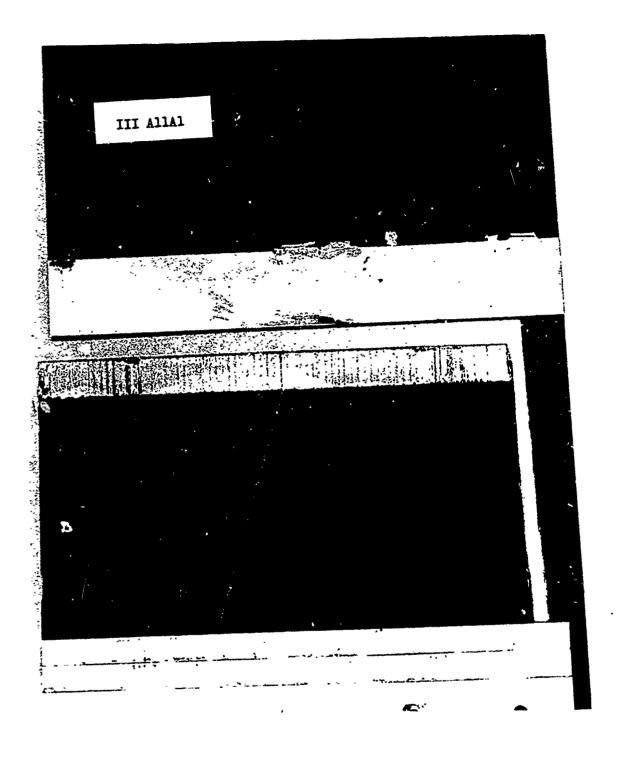


FIGURE 75 - CONTROL SPECIMEN FOR BORON/ALUMINUM CONFIGURATION A TEN-INCH WIDE SPECIMEN



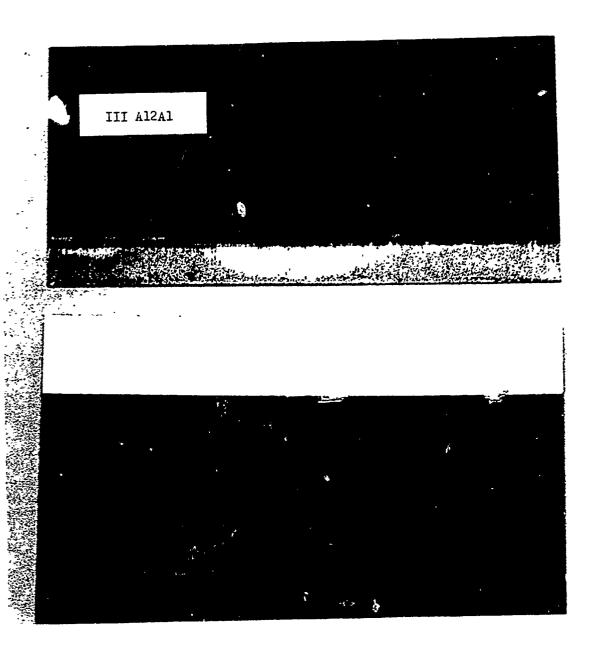
FIGURE 76 - CONTROL SPECIMEN FOR BORON/TITANIUM CONFIGURATION A TEN-INCH WIDE SPECIMEN



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Close examination indicate failure to initiate at the center of the specimen. The splitting of the laminate is probably secondary and due to partial bond failure at the tab end.

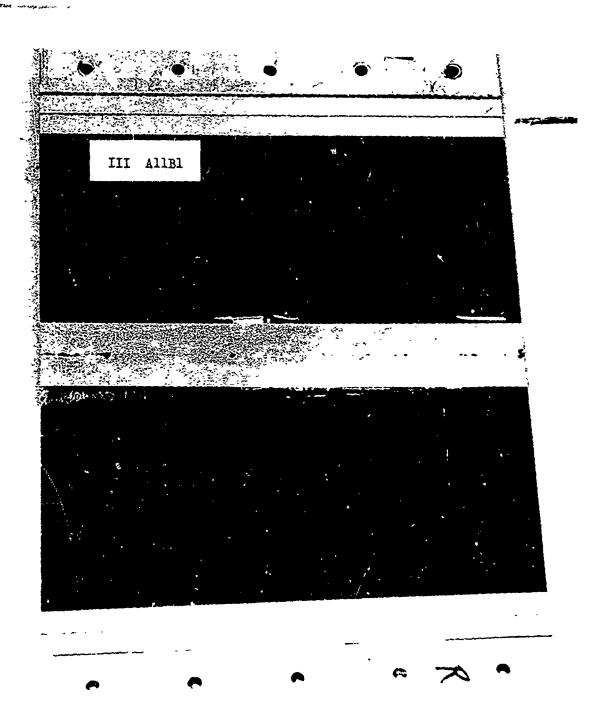
FIGURE 77 - CONFIGURATION A - TEN INCHES WIDE BORON/TITANIUM, STRESS RATIO $R=\pm\,0.1$



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Fatigue zone can be seen at center of specimen with what appears as static failure towards the edges. Note similarity between these static zones and the static failures of Figure 51.

FIGURE 78 - CONFIGURATION A - TEN INCHES WIDE BORON/ALUMINUM, STRESS RATIO R = + 0.1



Fatigue zone can be seen at center of specimen and static zone on the left side and unfailed 2.0° section on the right side.

FIGURE 79 - CONFIGURATION A - TEN INCHES WIDE BORON/TITANIUM, STRESS RATIO R=-1.0



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Note same failure pattern as shown in Figure 54.

FIGURE 80 – CONFIGURATION A – TEN INCHES WIDE BORON/ALUMINUM STRESS RATIO R = -1.0

4.6 BONDED JOINT TESTS - CONFIGURATION B - STEP LAP SCARF JOINT

4.6.1 Specimen Configuration

The Phase I, Configuration B specimen details are given in Dwg. No. 7226-1302IB, Appendix C. The Phase II and Phase III specimens were fabricated to the same drawing but the width dimension was increased to 3.0 and 10.0 inches respectively. Specimen ident: fication information is given in Tables VII, VIII and IX.

4.6.2 Test Procedure and Results - Phase I and Phase II

The Phase I tests were conducted in accordance with Table VII, and the test data were reported in Appendix B, Tables B10 thru B13. The Phase II tests were conducted in accordance with Table VIII, and the test data were reported in Appendix B, Table IIB2.

All the Configuration B, step lap scarf joints were supported with the same type of plates as those used on the Configuration A joints. The shim plates were modified to provide a cut-out for the thermocouple which was located at the scarf joint interface on the short side of the composite material. This convenient position was selected because a temperature survey utilizing three thermocouples positioned along the length of the joint had indicated that the temperature differential along the joint was negligible for all test stress levels. The gap between the joint and the support plates was maintained at approximately 0.003 inch on each side and over a length slightly greater than the length of the joint, as shown in Figure 81. A "T" section stiffener was added to the support plates when used on specimens that were subjected to compressive loading.

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Representative failure modes for a selection of Phase I specimens are presented in Figures 82 thru 85. Typical fatigue failures for the wider Phase II specimens are shown in Figures 86 and 87. Comparison of test data for the 1.0-inch wide joints with the data for the 3.0-inch wide joints shows that a majority of the 3.0-inch wide specimens exhibited longer fatigue lines than did the 1.0-inch wide specimens. This is a reversal of what was shown by a similar comparison for the Configuration A specimens which exhibited shorter

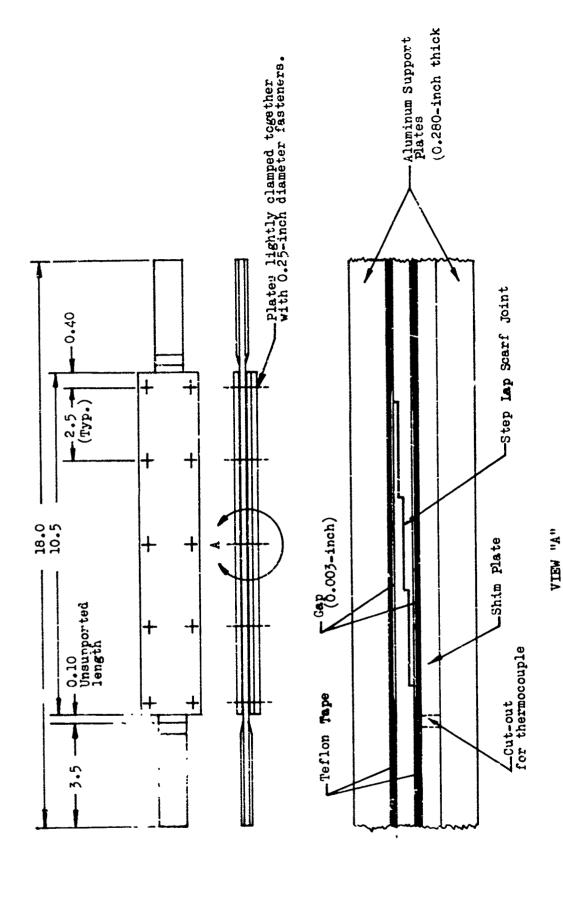
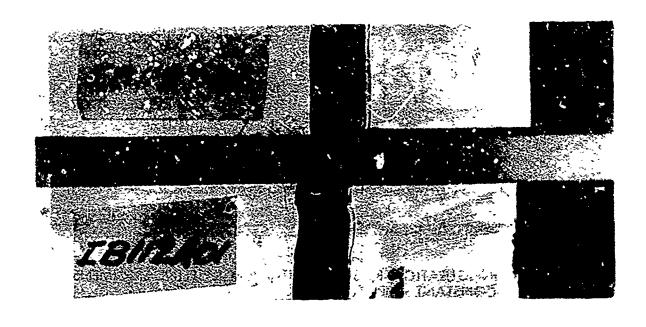


FIGURE 81 SUPPORT PLATE SYSTEM FOR TYPE "B" JOINT SPECIFIEN

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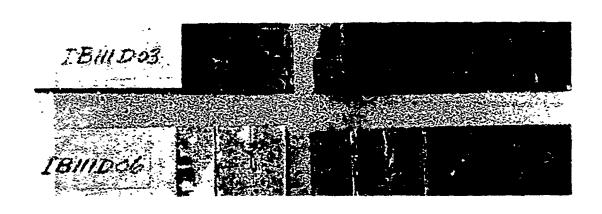
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-DO3 Typical static tensile failure in aluminum adherend -AO1 Typical $R = \pm 0.1$ fatigue failure in aluminum adherend

FIGURE 82 - CONFIGURATION B, BORON/ALUMINUM BASELINE SPECIMEN

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-DO3 Static tensile failure with partial interlaminar shear -DO6 Static tensile shear failure (mating fracture surfaces are shown)

FIGURE 83 - CONFIGURATION B, BORON/TITANIUM BASELINE SPECIMEN

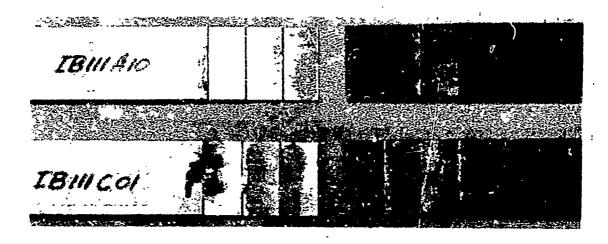


FIGURE 84 - CONFIGURATION B, BORON/TITANIUM BASELINE SPECIMENS CONSTANT AMPLITUDE FATIGUE TESTS

-AlO Typical R = +0.1 fatigue failure in joint -CO1 Typical R = +10.0 fatigue failure in joint with minor laminate damage (mating fracture surfaces shown)

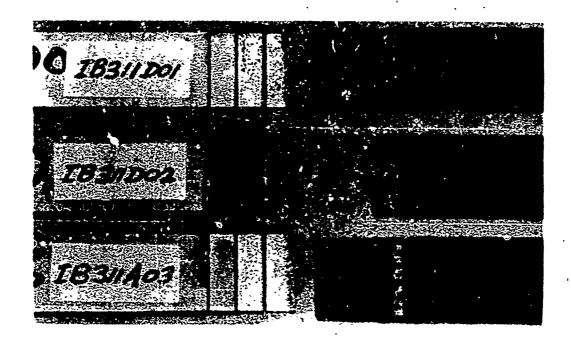
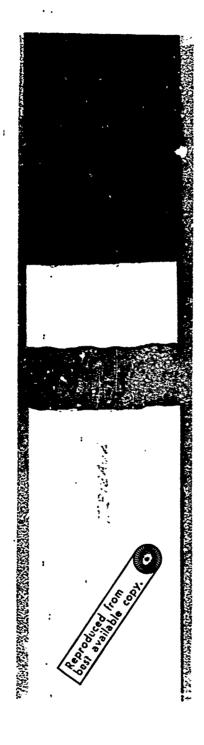


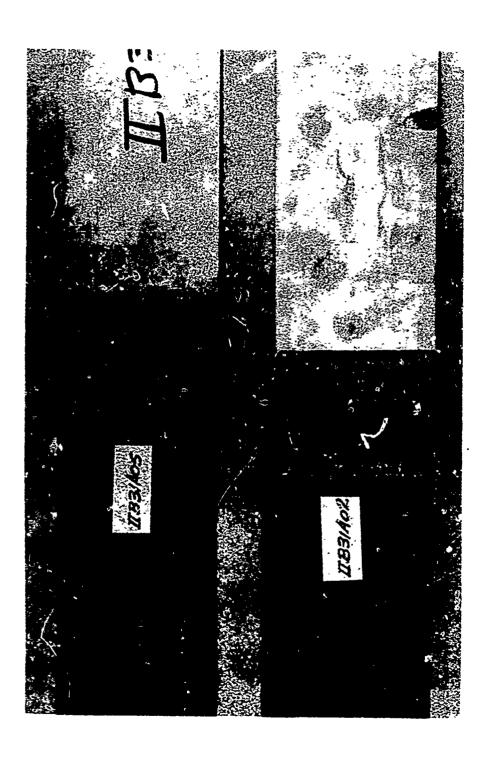
FIGURE 85 - CONFIGURATION B, BORON/TITANIUM SHORT LAP LENGTH

- -DO1 Static tensile shear failure
- -DO2 Static tensile failure with partial interlaminar shear
- -A03 Typical R = +0.1 fatigue failure in joint (mating fracture surfaces shown)



-AO2 Typical R = +0.1 fatigue failure in metal

FIGURE 86 - CONFIGURATION B, THREE INCHES WIDE BORON/ALUMINUM, STEP LAP SCARF JOINT



-A05 R = +0.1 fatigue failure in joint and partial laminate failure -A02 R = +0.1 fatigue failure in joint

FIGURE 87 - CONFIGURATION B, THREE INCHES WIDE SHORT OVERLAP BORON/TITANIUM, STEP LAP SCARF JOINT

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fatigue life with increase in specimen width. The 3.0-inch wide boron-to-aluminum specimens, however, behaved in a more predictable manner due to the mode of failure for this configuration. All failures occurred in the aluminum adherend after approximately the same number of cycles and at the same stress level as did the equivalent 1.0-inch wide step joints.

4.6.3 Test Procedures and Results - Phase III

The Phase III tests were conducted in accordance with Table IX, and the test data are reported in Appendix B, Table IIIB2.

The test procedure used for the ten-inch wide Configuration B specimens was essentially the same as those used for the Configuration A ten-inch wide specimens. A similar support plate system was used but the shim plates were modified to accommodate the different joint configuration. The increase in fatigue life exhibited by the 3.0-inch wide specimens was again exhibited by the ten-inch specimens, i.e., the ten-inch specimens developed longer fatigue life than did the one-inch and three-inch wide specimens.

4.7 BONDED JOINT TESTS - CONFIGURATION C - TEE SUPPORT JOINT

4.7.1 Specimen Configuration

The Phase I, Configuration C specimen details are given in Dwg. No. 7226-1302IC, Appendix C, and specimen identification information is given on Table VII.

4.7.2 Test Procedure and Results

Tests were conducted in accordance with Table VII, and the test data are reported in Appendix B, Table B14.

A specially designed support and side loading fixture was used for all tests. The fixture was fabricated to the configuration shown in Figure 88 and consists of two lateral support plates with two stiffener plates attached to one of the lateral plates. The same plate has a cut-out at the center to allow the tee piece of the specimen to pass through. A strain-gaged link, in the form of a fork-end with a threaded shank, is attached to the tee and the threaded end passes through a reaction plate mounted to the stiffener plates. Originally a coil spring was located between the reaction plate and the end of the shank of the link and was held in place by a nut and washer. Later developments, however, resulted in the coil spring being replaced by two pieces of 0.125 inch thick rubber sandwiched between the reaction plate and a large 0.10 inch thick aluminum washer. Load was applied to the tee by turning the nut on the calibrated strain-gaged link. The magnitude and shape of the lateral deflection along the length of the specimen adherend is controlled by the type of shimming used between the specimen and the support plates, and by the magnitude of the applied axial load. After evaluating various systems it was found that a tapered aluminum shim and soft rubber sheet combination provided the desired deflection pattern. The aluminum shims were 0.150 inch thick at the tub end and feather-edged at the other end near the tee. The soft rubber was approximately 0.50 inch thick and the same length as the shim. One piece of rubber and one shim were sandwiched between the specimen adherend and the upper support plate on each side of the tee joint.

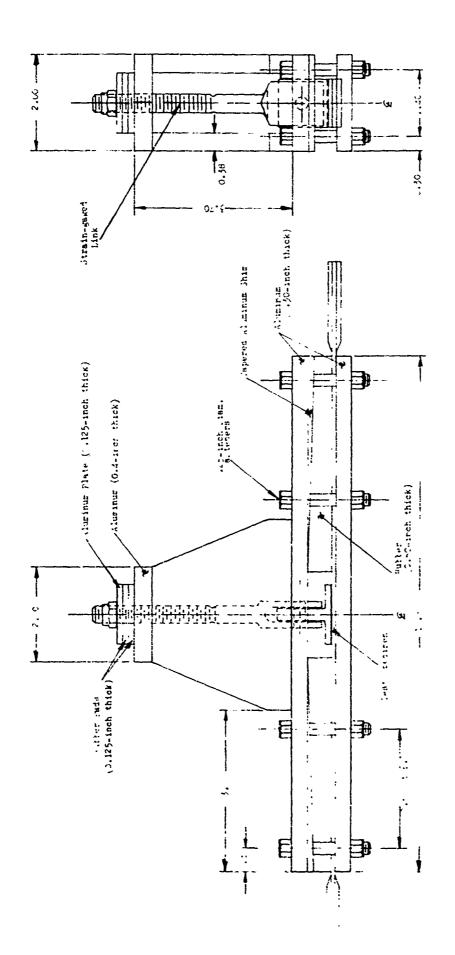
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FIGURE 88 - TEST FIXTURE FOR CONFIGURATION C AND CONFIGURATION F SPECIMENS

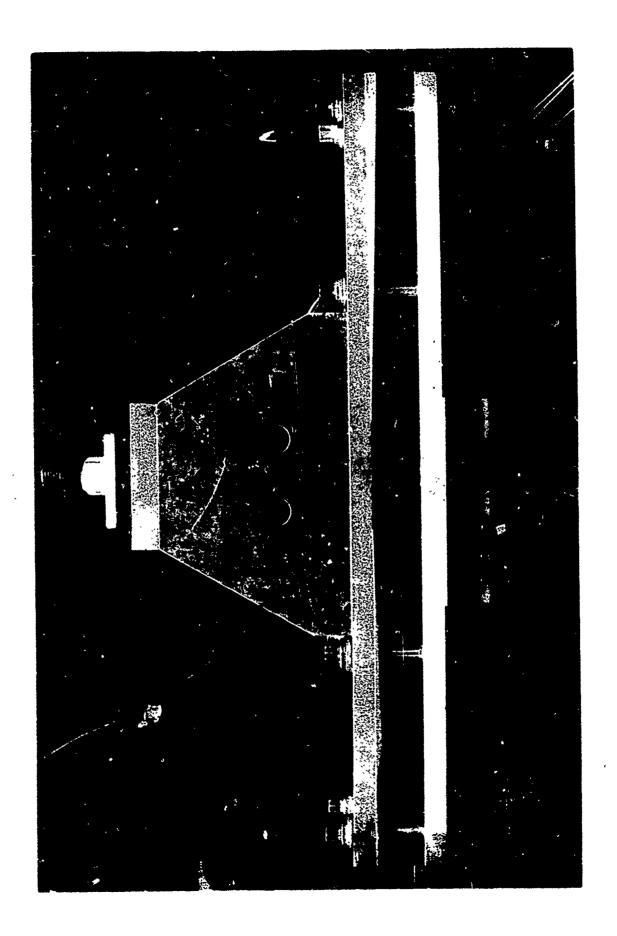
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The static tests were conducted by maintaining a selected axial load on each specimen and then determining the side load required to fail the tee-to-specimen bond. The selected axial loads were representative of the range anticipated for the fatigue tests. The test set-up for the fatigue tests is shown in Figure 89. After the mean axial load had been applied to the specimen, the side load (based on the results of the static tests) was applied to the tee. A typical test specimen with mean axial and side loads applied is shown in Figure 90. Application of the dynamic axial load caused a variation in the side load which was monitored on the calibrated stripchart recorder. Each specimen had a thermocouple bonded to the adherend at the edge of the tee. Failure of the bond between the tee and boron resulted in a straightening of the boron adherend which in turn triggered the micro-switch and stopped the machine.

A photograph of a failure specimen immediately prior to failure is presented in Figure 91.

Failures generally occurred in the resin adjacent to the fibers in the surface ply as illustrated in Figures 92 and 93. One fatigue specimen, however, had an unusual failure mode as shown in Figure 94. This specimen had a partial tensile failure in the boron resulting in interlaminar shear failure over a large portion of the laminate.

FIGURE 89 Test Fixture For Configuration C Bonded Tee Joint



Test Set-Up for Configuration C Specimen (Mean Axial and Side Loads Applied)

FIGURE 90

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Configuration C Specimen Under Fatigue Loading Just Frior to Failure

FIGURE 91

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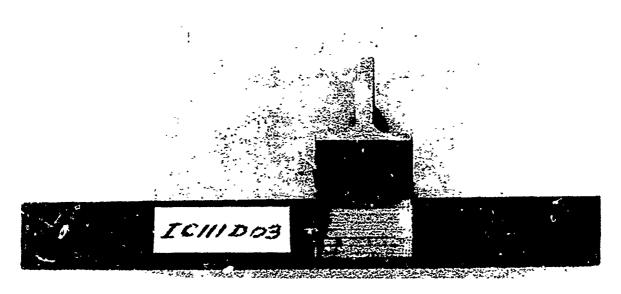


Figure 92 Configuration C, Titanium Tee/Eoron Static Test



Figure 93 Configuration C. Titanium Tee/Ecron Fatigue Test R = +C.1 Typical Failure



Partial tensile failure and interlaminar shear

FIGURE 94 - CONFIGURATION C, TITANIUM TEE/BORON FATIGUE TEST R = + 0.1

4.8 CONFIGURATION D - DOUBLE JOINT TESTS

4.8.1 Specimen Configuration

Details of the Configuration D specimen are given in Drawing No. 7226-1302ID, Appendix C. Specimen identification information is given on Table VII.

4.8.2 Test Procedure and Results

Tests were conducted in accordance with Table VII, and the test data are reported in Appendix B, Table B15 and B16.

Since the double strap joints of the Configuration D specimens were balanced, lateral support plates were not necessary. Specimen temperature was measured with a thermocouple bonded to the adherend adjacent to the end of a splice plate. In all other respects the test procedures were similar to those used for the Configuration A specimens. Static and fatigue failure modes for the titanium splice plate specimens are shown in Figures 95 and 96. The catastrophic failure shown in Figure 95 was typical for all static tests. Failure modes for the boron splice plate specimens are shown in Figure 97. Static test specimens failed in tension across the splice plates, but the fatigue specimens failed in shear at the joint similar to the fatigue failures for the titanium splice plate specimens: Test results for these Configuration D specimens were comparable to the results obtained with the baseline Configuration A specimens. This close comparison verifies that the support plates used with the Configuration A specimens provided just the correct amount of support to the joint area. This permits all Configuration A and D data to be used in conjunction with the analysis procedures discussed it. Volume 1 of this report.

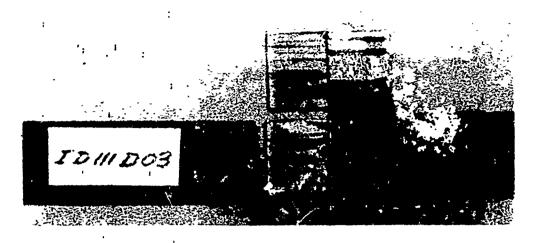


Figure 95 Configuration D, Boron/Titanium, Static Test Titanium Splice Plates

-DO3 Typical static tensile failure

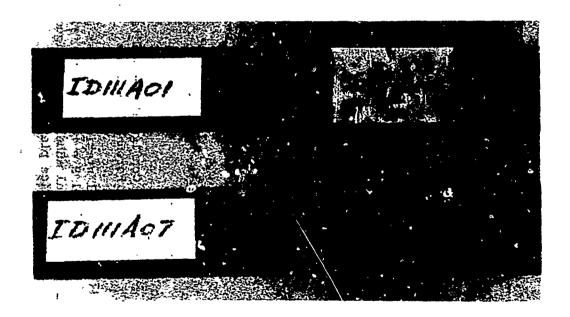


Figure 96 Configuration D, Ecron/Titanium, Fatigue Tests R = +0.1 Titanium Splice Plates

-AO1 Failure between boron and both splice plates on one end

-A07 Failure of one splice plate at both emis and failure of other splice plate at one end

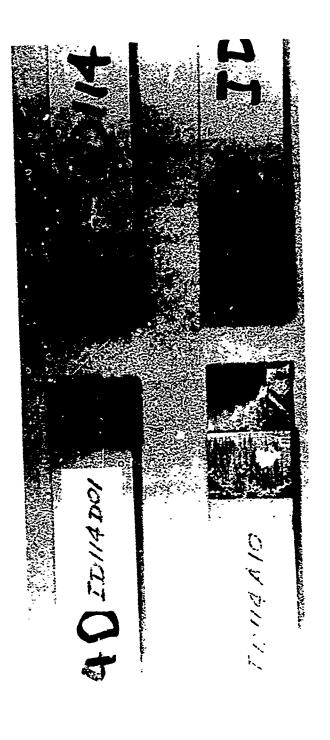


Figure 97 Configuration D, Titanium/Boron Static and Fatigue Boron Splice Plate

-DOI Typical static failure-net section in splice plate
-AlO Typical R = +O.1 fatigue failure shear failure in ply adjacent
to metal adherends. Fatigue damage can also be seen at center
of splice plate

4.9 BONDED JOINT-CUMULATIVE DAMAGE TESTS

4.9.1 Specimen Configuration

One-inch and three-inch wide Configuration A specimens were fabricated for the Phase I and Phase II cumulative damage tests. A ten-inch wide, modified Configuration A specimen and a ten-inch wide, modified configuration B specimen were fabricated for the Phase III cumulative damage tests.

4.9.2 Test Procedure and Results

Phase I tests were carried out in accordance with Table VII, and the test data are reported in Appendix B, Table B3. Phase II tests were carried out in accordance with Table VIII, and the test data are reported in Appendix B, Table IIB1. Phase III tests were carried out in accordance with Table IX, and the test data are reported in Appendix B, Table IIIB.

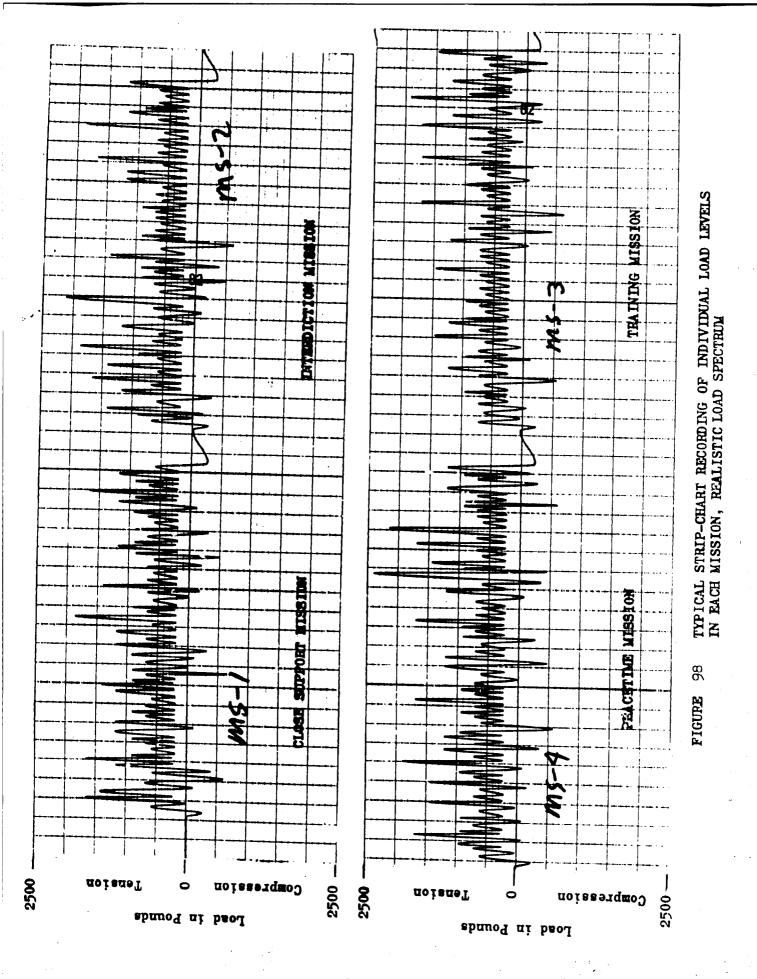
The cumulative damage tests were conducted using the same support plate systems that were selected for the appropriate baseline data specimens tested in each of the three Phases. The same programming equipment was used for all testing and is described in detail in section 4.2.3. Two software programs were used to prepare the computer for either block loading format or realistic loading format. Both types of loading programs are described in Volume III, Section 2.3.

During the testing of the Phase I specimens, some failures occurred in the adherend material between the end of the support plates and the tab end of the specimen. The cause of these premature failures was not determined. However, sufficient contingency specimens were available to complete the required number of cumulative damage tests with valid joint failures. The maximum and minimum load levels of each individual block were measured on the MTS load amplitude measurement equipment in addition to being continually monitored on a calibrated Clevite-Brush strip-chart recorder. Correlation between the two load measuring systems was very good and since the MTS measuring

equipment cannot measure sirgle load levels the strip-chart recorder was used for determining the actual applied loads for the realistic spectrum testing. A typical strip-chart recording showing all the load levels in each of four different missions is shown in Figure 98. A one "g" value that corresponded to a joint shear stress of 330 psi was used for both the block and realistic spectrum loading in Phase I.

Since only five cumulative damage tests were scheduled in Phase II it was not possible to use both types of loading spectrum. The realistic spectrum loading was finally selected since it was believed that this type of loading would produce the most useful test data. Three specimens were tested at a one "g" value that corresponded to a joint shear stress of 290 psi and the other two at a joint shear stress of 260 psi.

The Phase III, 10.0-inch wide specimens were tested using the block loading spectrum adopted originally for the Phase I bonded joint tests. Both the Configuration A and Configuration B specimens were loaded to a maximum average joint shear stress level of 2000 psi (10 "g" load level). The same stress level was selected for each test because it was believed that the results would provide useful comparative damage data in the two joint configurations. Good failures were obtained from both tests, the Configuration A specimen failed after 2.5 lifetimes (25 blocks) and the Configuration B after about 6.1 lifetimes.



4.10 MECHANICAL JOINT TESTS - CONFIGURATION E - SINGLE SPLICE BUTT JOINT

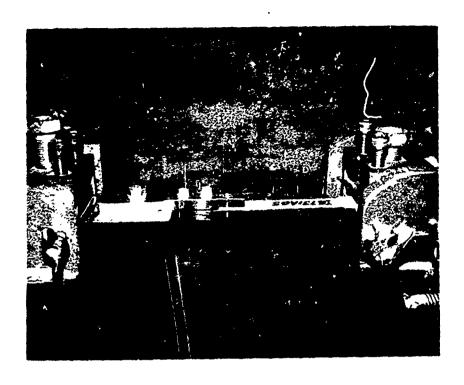
4.10.1 Specimen Configuration

Phase I, one-inch wide and Phase II, 2.0-inch wide specimen details are given in Dwg. No. 7226-1302IE, Appendix C. Specimen identification information is given on Table X.

4.10.2 Test Procedure and Results

The tests were conducted in accordance with Table X and the test data are reported in Appendix B, Table IVB1 thru IVB4.

Pin pearing static strengths were determined in a universal testing machine and all fatigue tests were conducted in Lockheed designed fatigue machines. The same pinbearing test fixture was used for all tests. This fixture is shown in a typical fatigue test set-up in It consisted of two steel bars, one clamped on each side of the end of the test specimen, and load was introduced to the specimen through a 0.187 inch diameter steel pin. During each static test, hole deformation was measured with a 2.0-inch gage length extensometer. One pair of the extensometer knife edges were attached to the edges of the specimen in line with the pin loading hole and the other pair of knife edges were attached to the test fixture. Load versus deformation was plotted on an autographic recorder. Since there were only five fatique specimens within a group, one specimen was fatigue tested at each of five different stress levels. Photographs of typical failures are presented in Figures 100, 101, and 102. The test data were exceptionally consistent enabling good fatigue trend lines to be determined for the different specimen configurations. Data generated included the evaluation of a 0°/±45° reinforced with titanium shims and with additional ±45° plies. The effect of edge distance was also evaluated with the specimens using titanium shims as the reinforcement material in the joint area.



(General View)



(Time-up Ties)

Figure 39 Pin Pearing Test Set-Up





IE711A02

Figure 100 Pin Bear. 79 Decimen (00/+450)
Titanium Relatorced, e/D = 2.0 _DO2 Typical Static Failure _AO2 Typical R = +0.1 Fatigue Failure



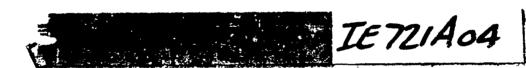


Figure 101 Pin Bearing Specimen $(0^{\circ}/\pm45^{\circ})$ Titanium Reinforced, e/D = 1.5_DO3 Typical Static Failure -A04 Typical R = +0.1 Fatigue Failure

Originally, the Configuration E single splice butt join, specimens were fabricated with aluminum straps and splice plates but initial testing of these resulted in premature failures of the aluminum at the joint net sections. It was assumed that failure may have been encouraged by the countersink in the aluminum strap, therefore testing of these specimens was discontinued to allow further investigation. Two specimens were reassembled with titanium straps having the same type of flush head fastener. Premature failures still occurred at the net section of the titanium portion of the joint and the subsequent substitution of protruding head fasteners still did not produce the required boron failures. However, the final design discussed in the Fabrication Section was tested and acceptable failures were obtained in the boron material. All the mechanically fastened joint specimens were tested in the same testing machines that were used for the bonJed joint specimens and a similar support plate system was used. Holes were cut in the support plates to accommodate the fastener collars and the gap between the support plates and the specimen in the splice area was maintained at approximately 0.003 inches. The specimens were supported at equal distances on each side of the joint as shown in Figure 103. The actual distance for a given group of specimens was determined by the length of the tapered section in the boron composite where the titanium shims were inserted. Allen wrenches were placed in the ends of the fasteners in order to detect any rotation of the collars or fasteners during fatigue testing. A typical fatigue test set-up with allen wrenches in position and with each location marked in relation to the support plates is shown in Figure 104. position was also marked relative to the wrench position. Numerous tests confirmed that no rotation had occurred in either the fasteners or collars therefore the procedures adopted for determining rotation were discontinued. Selection of the stress levels for the fatigue tests was based on the results of the pinned joint/edge distance evaluation tests. Excessive heating (over 10° Fahrenheit rise above ambient) was experienced during the initial fatigue testing but effective control was obtained by blowing cool air over the joints with the arrangement shown in Figure 105. Photographs of typical failures are presented for the 1.0-inch wide specimens in Figures 106 thru 111 and for the 2.0-inch wide specimens in Figures 112 and 113. Failures for specimens tested at a stress ratio of R = +0.1usually occurred in the net section area of the shimmed boron through a fastener hole, or at the edge of the shim reinforcement in the basic boron laminate; however, one failure occurred in the titanium splice plate. This splice plate failure suggests that the shimmed

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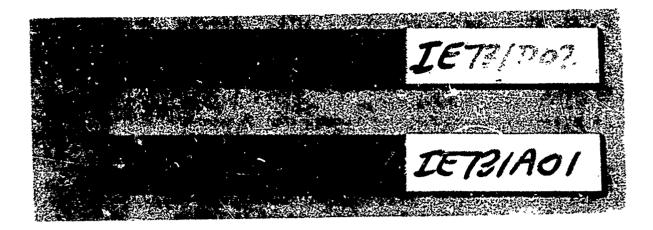
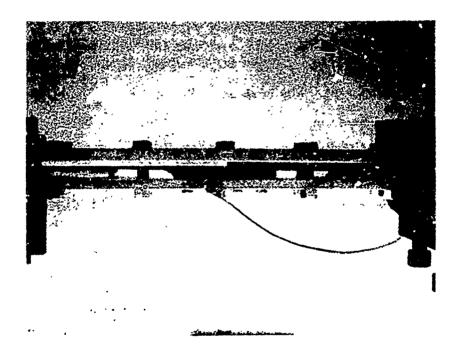


Figure 102 Pin Bearing Specimen $(9^{\circ}/\pm 45^{\circ})$ $\pm 45^{\circ}$ Boron Reinforced, $\epsilon/D = 2.0$ -D02 Typical Static Failure -A01 Typical R = +0.1 Fatigue Failure



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Figure 103 Mechanical Joints With Support Plates

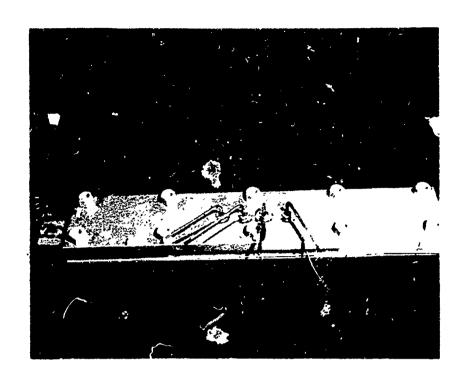


Figure 104 Test Set-Up For Monitoring Fastener Rotation

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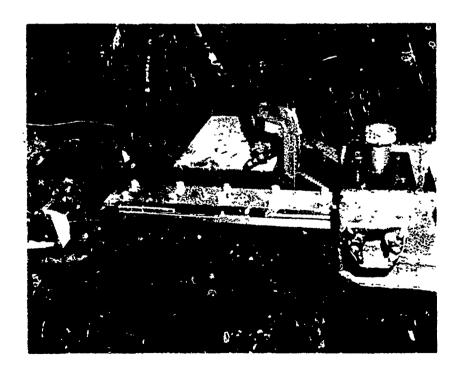
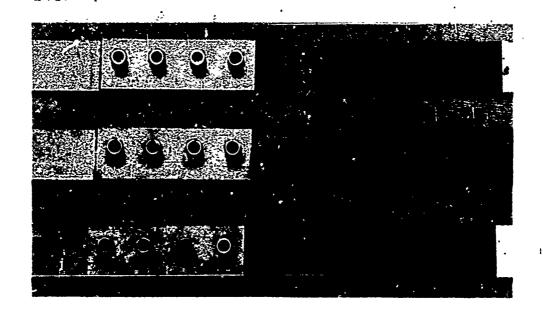


Figure 105 Set-To For Maintaining Specimen Temperature



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Figure 106 Configuration E, Baseline
(0°/±45°) Boron/Titanium
-D05 Typical Static Tensile Failure
-A02 Typical R = +0.1 Fatigue Failure
-D02 Typical Static Compression Failure

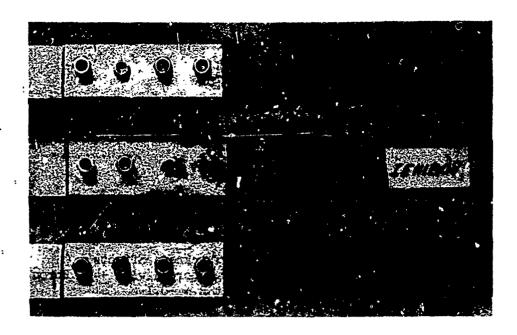


Figure 107 Configuration E, Baseline, R = -1.0
(0 /+45) Boron/Titanium
- Shown are three different types of failure.

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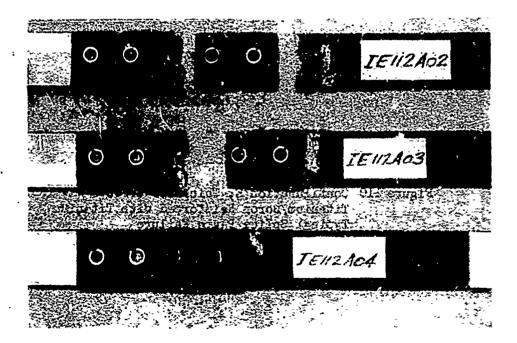
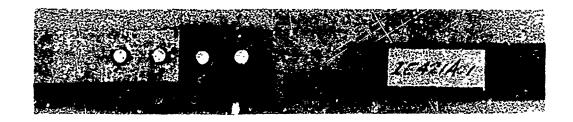


Figure 108 Configuration E, Baseline, R = +0.1
Boron/Boron (0°/+45° with titanium inserts)
- Shown are three different types of failure.



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Figure 109 Configuration E, Thickness Effects
Titanium/Boron, Reinforced with +45° Boron
Typical Failure at R = +0.1

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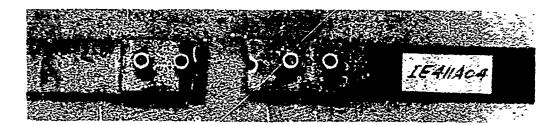


Figure 110 Configuration E, Thickness Effects
Titanium/Boron Reinforced with Titanium
Typical Splice Plate Failure

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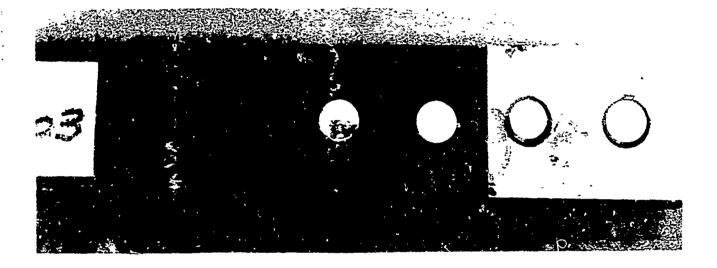
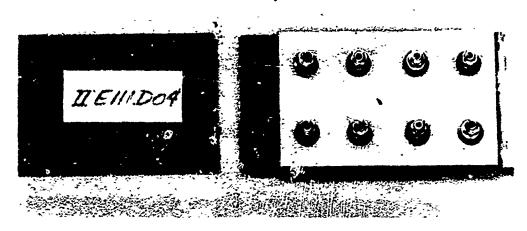


Figure 111 Configuration E, Short Edge Distance Boron/Titanium, Titanium Shims in Boron

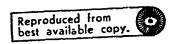
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Fatigue damage can be seen at net section of boron and also at edge of shim build-up section. Fatigue test was discontinued after specimen (IE311A03) had endured 13×10^5 cycles at R = +0.1.



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Figure 112 Configuration E, Two Inches Wide, Baseline Typical Static Tensile Failure



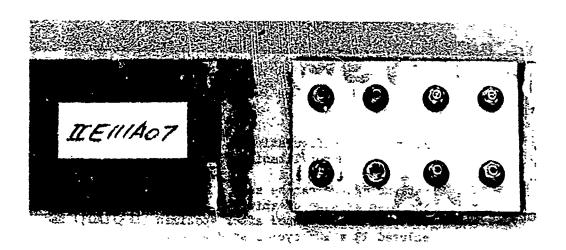


Figure 113 Configuration E, Two Inches Wide, Baseline Typical R = +0.1 Fatigue Failure

boron has fatigue strength equal to or greater than titanium having up to 50 percent more net-section area.

Repeated attempts to obtain fatigue failures in the joints of the baseline specimens tested at a stress ratio of $R = \pm 10.0$ were unsuccessful. Testing at this stress ratio was therefore discontinued, and all remaining test specimens were used for contingency or supplementary tests, as required, for providing additional test data to better define a test variable. For the specimens tested at a stress ratio of R = -1.0 the majority of failures occurred in the fasteriers. Initially these failures were attributed to excessive bending action at the joint during reversed cycling. It was believed that the 0.003 inch clearance between the joint and the support plates was allowing excessive bending of the splice plate which results in repeated tension loading of the fastener through the steel collar. Subsequent testing with no clearance around the joint how ever, still resulted in some fastener fatigue failures.

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4.11 MECHANICAL JOINT TESTS - CONFIGURATION F - TEE JOINT

4.11.1 Specimen Configuration

Specimen details are given in Dwg. No. 7226-1302IF, Appendix C, and specimen identification information is given on Table X.

4.11.2 Test Procedure and Results

Tests were conducted in accordance with Table X, and test data are reported in Appendix B, table IVB5.

A different test procedure was used for the Configuration F static tests than was previously used for the Configuration C (bonded tee joint) static tests. Since the mechanically fastened tee was capable of withstanding a considerably higher load than the bonded tee, emphasis was placed on axial load carrying capability. The support fixture that was used for the bonded tee specimens was modified to accommodate the longer leg of the mechanically fastened tee. Two specimens were tested using the same transverse loads that were used previously with two of the bonded tees and then the specimens were loaded axially to failure. Both failures occurred in the boron laminate at the edge of the titanium built-up section as shown in Figure 114.

The fatigue tests were conducted in the Lockheed designed fatigue machines using a similar testing procedure to that used for the bonded tee joint specimens. The baseline data specimens were tested at a stress ratio of R = +0.1 and at a maximum axial stress of 40,000 psi at the net section of the shimmed boron. A side load of 100 pounds was used on five specimens and a sideload of 250 pounds was used on the other five. The increased thickness specimens were tested in a similar manner but the maximum axial stress level was 35,000 psi and the side load was 500 pounds. Fatigue failures occurred at either the net section or at the edge of the shimmed boron section. The test results confirmed that the fatigue strength of the joint decreased with increased side load as expected.

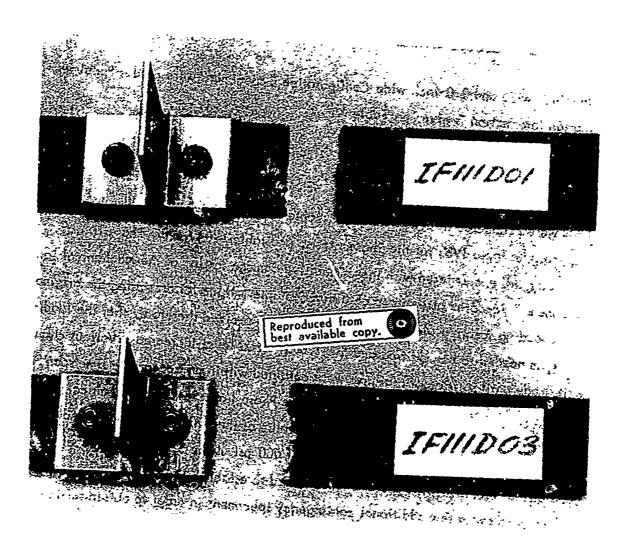


Figure 114 Configuration F Baseline Static Tests

_DO1 Side Load Held Constant, Axial Load
Increased to Failure

_DO3 Axial Load Held Constant, Side Load
Increased to Failure

4.12 MECHANIAL JOINT TESTS - CUMULATIVE DAMAGE

4.12.1 Specimen Configuration

One-inch wide and 2.0-inch wide Configuration Especimens were used. Specimen identification information is given on Table X.

4.12.? Test Procedure and Results

Tests were conducted in accordance with Table X, and the test data are reported in Appendix B; table IVB1 for the Phase I tests, and table IVB4 for the Phase II tests. Some difficulty was encountered with the cumulative damage testing of the mechanical joint specimens. Repeated attempts to obtain acceptable fatigue failures using the original block loading spectrum were unsuccessful. It was decided therefore, that the loading spectrum needed to be modified and the 1.0 "g" load level increased. Various changes were made until satisfactory failures were obtained within an acceptable time span. The spectrum that was finally adopted for both the Phase I and Phase II mechanical joint specimens is presented in Table XI. The value of the 1.0 "g" load was selected to give a joint net section stress of approximately 39,000 psi at the 8.0 "g" load level Since most of the 1.0-inch wide specimens were used to establish the loading spectrum, it was necessary to test a few additional contingency specimens in ruder to obtain sufficient data points for spectrum evaluation. The Phase I and Phase II realistic loading spectrum to us were conducted without any difficulties. In both cases the selection of the 1.0 "a" load level was based on the results of the block spectrum testing. All tests were conducted in the computer controlled MTS testing machine and the specimens were supported in the same manner as the Configuration E baseline specimens. All failures occurred at either the joint net section or at the edge of the titanium shim reinforcement.

4.13 SUMMARY

All data generated during this test phase has been plotted in S-N form and is included in Volume III, Section 2, Fatigue Analysis. In that section all results are analyzed, compared, and discussed in detail.

TABLE XI

TRUNCATED BLOCK SPECTRUM LOADINGS

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APPENDIX A

FABRICATION AND INSPECTION LOGS

Fabrication and inspection details for all panels and specimens are summaries and recorded on the forms included herein. This Appendix is separated into sections by table numbers where each of the tables represent a particular group of specimens as defined by program phase, specimen configuration, drawing number, and specimen number.

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n werr obteined for all specimens and will be kert on file for comparison with the fasted ion	Maelignent	050*	<u>'</u>			-	-		-	030						**	1				
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Note 11 Famel material 10 Ct. 1-1 C: tenfum short.		- +	-		-																1
Note 11 Fame material 19 (4.1-1 2: tenfilm anothe.						ļ								_							
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September (INDESTRICTORS) FREE CONTROL OF STREET OF STRE

										4	LOCKH	EED-GEORG	LOCKHEED-GEORGIA COMPANY A COMPANY OF LOCKHEED AIRCRAFT COMPORATION	MEDGET PO TABLE AS cont.
					MATE	MATERIAL VEH	PICATION	IAL WEHIPICATION AND CHECK PABRICATION AND INSTECTION	53	TEST SIECTMEN (ADHESTVE)	JTMb.K i)			
Specimen W. 73	73421 175422	V3A23	73.824	73425	73431	V3A52	V3A33 V	V3A34 V	V3A35 V	V3A36 1	V3A27	V5A38		
_		Ø.	Note 1				-	-		1	1	-		
Tab Material		- 78'F -		1			1	NONE	+			•		
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	•	0.1218		+	0.1.16 0	0.1210	0.1216 C.	C.1215 0.	0.1210 0.	0,1211	6,1715	0.1210		
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2. The appealment on this page	or thin Pa	roz ozu	use in	use in entablishing lo		r nupper	r proceed	पर्वं व्या	nt nuppert procedures prior to testing t		COHDO	ne_composite_joinia		
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				ž	BONDED JOI PROGRA	£	SPECI ANS - PABRICATION AND INSPECTION LCC	MION AND IN	SPECTION LCC	PRAST	1	CONFIGURATION A	£		
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e Material	6A1-4V-Titenius	Annesles			:	•									
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(2) Man: side is the mane as left since nominal	0 100 00 10	oft since	nomina	thickn	thicknesses rep	orded		- 4			_				
(3) Bouble overgian butt Joint for photo-stress pvaluation	utt Joint h	r photo-	stress ;	we lust:	 ∙ i		-								
Scinte (Alligat thru Lais of mrs of male to the section	90 3711VL U	1re to	a; ente	1901. 695.	- proc	dures					-	-	-		
(4) All specimens or	tore sheet	are trie	h. odg 11	ch: to		n testing	proced res			-				-	-
and time taktors. There are not gart of the tasts thase I r	These are	not jar	t of the	1 001001		pozy ba	Spectmens	-		 - -					-
o it will be uned to rompledent the required tests.	to complete	ont the 1	required	tests.	í	+ :	-	 			_				-
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												LOCK)	HEED-GE	DRGIA CO	LOCKHEED-GEORGIA COMPANY A DIVINON OF LOCKHEED AIRCRAFT COMPONATION	I	112	Non L	Table 4-3	
						HONDEL	TO JOINT	SPECIMEN	D JOINT SPECIMENS - PABPICATION AND INSPECTION LOG W PBASE AND SPECIMEN IDENTIFICATION NUMBER	TCATION A	TON NUMB	CTION LO		PEASE I -	CONFIGURATION	WITTON A				
Speciaen No. Inil	1001	11,02	1503	1,401	1402	1403	1404	1405	1406	1407	1408	1409	1410	1801	1802	1803	1804	1805	1806	1807
Penel Ident.	IA11																			1
ho Ident.	707576	7075T6 Aluminum								-	-									1
Adnerend Thickness					_			_												
; J e.;	.0437	.0438	.0434	.3440	.0441	.0441	.0436	.0435	.0449	0440	.0437	.3436	.0433	.0439	.0439	.0438	.0439	.0438	.0435	.0439
Hight	.0435		.0433		_	.0434	.0441	.0436	.0437	.0437	.0438	.0435	.0434	.0436	.0440	.0440	.0435	.0437	.0434	35.00.
plice Mat.	6A1-47-		Annsele	1				ш.	-				·							1
Splice Thickness																				
Laft	10,0	,040	0400	.040.	.0599	.0421	.0398	.0399	.0398	9680.	.0402	.0412	.0415	.0414	.0414	.0411	.0407	.0407	.0405	.0405
31,60	1010	_	.0401	1040	0333	_	_	,0398	.0399	.0400	.0401	.0414	.0414	.0411	.0412	.0409	.0406	.0405	.0404	.0405
	90-1096 V3		- 1 -			-		-												1
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iure Date	7-51								_											
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Heat-12 fate	70/01	15.DR # \$16579	116579	 -	-					:										1
Cure Temp./Time.	2500/13	: :	! ! !		 	-	 												Ì	İ
Jatot Intoknese	`					-							 							j
Left	.0995	,0993	,0941	,0961	6660	.0892	.0977	.0875	.0887	.0879	•C979	.0844	1::00.	.0392	.0895	.0889	.0886	9860.	.0883	.086
31tht	.0991	.0430	.0980	.0379	.0877	.0975	.0983	.0975	.0976	.0977	.0880	.0894	0690	.0889	.0894	0680.	.0885	.0084	.0882	.0863
Bendline Thinks Mils					_															İ
ieft	3:4:	4.4	4.7	4.0	4.4	4.0	4.3	4.1	1.0	4.0	4.0	4.5	4.3	3.9	4.2	4.0	4.1	4:1	4:3	7:
Plent	4.5	4.5	4.5	4.3	9.0	4.2	4.4		4.0	4.0	4:1	4.5	4.2	4.1	4.2	4.1	4.4	4.2	4.4	÷
Ingrest				-	 		_	_	_					İ						
SUBLICK ABBUE.	01:0	Ultragonic C-ace is and X-ray performed on all	000 100	4 x-ray	per(ora	I on B	specimens R.	ne R. E.	Shupe											
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	-																			
MOTES] 				_			_		-				_		-			
.[1] All specimens respected on this page and contidered unacceptable d	do papados	thie pa	c sug c	pheldere	d unacet	ptable	\$ to	very poor	onb puod	ity and		-								
K A A A A A A A A A A A A A A A A A A A		Intermitate anything the	11877	10000	TITL BILLIANS															
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COMPANY	UT COMPORATION
LOCKHEED-GEORGIA	A BIVISION OF LOCKHEED AIRCRAFT CORPORATION

A COLLEGE OF THE SECOND STATES

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						BONDED	CCRAM PH	ASE AND S	RD JOINT ST ZIMENS - PAP CCATION AND INSPECTION PROGRAM PHASE AND SPECIMEN IDENTIFICATION NUMBER	IDENTIFE	AND INSPECTION LOC FICATION NUMBER	TTON LOG UMBER		PRASE I - (CONFIGURATE ON	ATE ON A				
Specimen No. IAll	1,808	1 B09	1910	1001	1002	1003	1004	1005	1006	1001	1009	1009	1010	1004	1005	1006	1411	1412	1413	1414
Penel Ident,	IA11							Т		+	H		↑	IA1						•
Tob Ident.	7075 T-45 A1	6 A1 —					-		+				1	7075T-4	4 : —					•
Adherend Thickness																				
7307	,0433	.0436	.0436	.0419	.0436	9810	.0438	.0435	.0438	.0435	.0428	.0427	,0428	.0435	.0435	.0431	.0435	5620	.0433	10434
Richt	.0434	10437	10454	-043E	.04%5	7840	10439	 	40437	10434	.9431	.0432	0428	.0432	.0431	.0435	92.40	BE 7.1	1210	0435
Splice Meterial	541-4V	6A1-4VLTi taniu	Annewl	P								-								•
Splice. Thickness.																				
Total	9070	B070*	1,70	- 2414 -	.0413	.0412	1110	1110	1190	1170	.0399	.0398	6680	00100	.0402	,0402	,0405	10801	.0399	0070
Right	0000	10409	45412	2413	.0412	2180	51301	0190	10411	0399	86501	.0397	0398	0000	10401	0070	20402	0399	0070	0398
Adbastyn Dyn	90-109673	8					٦П	Н					•	E4 9601-106						•
Adh. Batch/Roll	364-5/2												1	364-60	\ \ \					•
Lawain Data	72.31												1	8/6						
Layaup Time	2000								1				•	1000						
Cure Date	7-31									+			•	6/7						
Cure time	1500						+						1	0000	Ā	LDR 389610	610			1
Cura Prassure	30													30						
Heat-Up Rate	70/min	T.DR	#386579							Н	+		•	7°/min						
Cure Temp./Time	2500/7 5	_							-				II,		m tu					
Joint Thickness								_					,		1					
iore	.0881	9860,	989	.0907	.0895	2680.	.0892	.0889	.0891	.0488	.0877	.0877	.0875	(5)	9880*	იგგი•	6880	•0880°	.0879	.0883
Right	.0997	.0897	986.	.0846	.0991	.0890	.0892	_	.0890	•0880	.0879	.0877	.0880	(2)	•0 8 83	.088c	2880	.0883	.0882	. 0880
Bondline Thick, Mile																				
Left	4.2	4.2	4.4	5.4	4.6	4.2	4.0	4.3	4.2	4.2	5.0	5.2	4.8	(2)	100	4.7	6.4	4.7	4.7	6.4
Richt	4.5	4.1	4.4	4.5	4.4	4:1	4.0	4.3	4.2	4.7	5.0	8.9	5.4	(2)	5.1	1.5	6.9	9*1	1.8	4.7
Inspect								_		- 	_				-					
Quelity Assur.	Ultreso	ate C-ac	pue out	K-rayo P	Ultresonic C-scans and k-rays performed on a	=	paclmens	. R. E	Shupe				-							•
DNO #1226-1302IA-							1	1	1	1	-i	1	1	1A7B	1479	2480	1481	1482	1,4133	1484
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					REJECT SPECI	PECIMENS (1)	 -		#				1		_					
KOTES:						T			†-	-	-	1	+						 	
(1) Specimens 1808 than 1000 are considered unacceptable due to	FULCIO E	e const	lered un	cceptab	le due te	very	poor bond quality and wil	luality a	+	not be u	used for	rati gue	evaluation	 ig	 				1-	
	1.11004	ne stat	c teste	at tim	of mach	1 00	d was not	t measured for	d for So		;		8 10 08B	assumed	İ					
to be approximate, 5 mile thick.	.3 5 mil	thick.				1				-			-							
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Hangely and the contract of th

Specieen No. 1A:1 1415 Fanel ident. 1A11																			
IN:1					CECNOR	JOINT SP	ECTMENS	JOINT SPECIMENS - PABRICATION AND INSPECTION	TION AND	INSPECTION LOG	507 700	PHASE	H	COBFICURATION	TION A				
IALI			H		5 -	The second second		1101	1817	1815 1816	16 1817	17_1810	H		1B20 1G1	+	7275	1513	1 4
++	2 1A15	141	1818	1419	2 4		7	Н	H			-	#	\parallel	#	-	\parallel		
			 				-					+	1	H	+		Ħ		
	5-TA A1	#	$\prod_{i=1}^{n}$				+	-	-			-				1	1	1	
			-			+	1	┸	┸	╀	71.70	87.70	7.8 00	71.00	04 17	-1440	2442	1440	2442
10ft0494	94 0434	98 AO. MI	\$6 _ 20434_	10041	10137	20130		┸	1.	1	}_	}	_	_	\dashv	65.00	2442	T A A	d d
		i	12461. 48	1940	CFFC	8870	- 0444	1043	0442	26.20		H	⊬	+	4		╫		\uparrow
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				-		+	+	+	Ļ	↓_	╀	┞	7070	4040	0406	7070	2040	2000	1040
	0010.	0010	99 20402	A2424	3000	9070	9070	1	-	4-		3000	1	}-		.0404		.0402	189
	╁╾			7	10404	*0404	20405	,0404	-1-2000	.040.	┨	╁	╁┼	H					$ begin{picture}(1,0) \put(0,0){\line(1,0){10}} \put(0,0)$
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y Assur. Bondiline measurements, G-nean and X-ray inspect on - R. E. Shupe. There specimen held as continuously and when relected for testing they will be assigned a specimen number.	Right		6.2	6.2	6.7	6.2	5.1	5.7	5.5	8.8	6.5	5.6	0.9	6.3	5.8	5.6	5.8	9.9	7.9	-
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Quality Assur.	Bondline thickness, c-scan and x-ray inspection	thickre	80, C-80	× pun uv:	-ray 1h	spection	on all	spectmens	. E.	Shupe.					-		_	Γ
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1111110 .0835 .0835 **1**43.5 7.0 9 6.7 6.7 111409 .0835 **אַזּה** \$ 0. 6.5 6.7 9 111003 PHASE I - CCNFIGURATION EIM EIM & \$ \$ 0.9 0.9 9 6.5 30. 80€ ၀့ 6.7 7.5 6.7 a specimen number. 111408 TIM ₹ 180° ₹ 7.0 7.2 6.5 6.7 111D02 111A06 111A07 R. J. Brailey. .0835 180° 1410 7.0 7.2 7.5 6.7 8 E. Shupe BONDED JOINT SPECTMENS - FABRICATION AND INSPECTION PROGRAM PHASE AND SFECTMEN IDENTIFICATION NUMBER for testing they will be assigned ₹ 80° 1A08 1A09 **180°** 9 7.0 0. 7.0 Fabrication inspection per drawing perdormed on all specimens Hon - R. 켷 3 7.0 6.7 9 . 0 111405 1407 3 췅 0.7 7.2 7.5 6.7 Bondline thickness, ulfrasonic c-scan and x-ray i 111404 8 8 3 7.0 6.2 2.0 6.2 111403 LDR 428782 --when selected 1405 ₹ ₹, 7.2 6.5 6.2 6.7 1404 **.** 30 9 0.7 6.7 6.5 (1) 100111 Annealed con. Intency and <u></u> 1403 ą .083 6.2 6.0 6.2 6.5 7075-TO Aluminum 6AL-4V Ti tenium 山 111402 8 1402 . 8 6.2 6.7 6.5 5.5 m-1A1210 -200/50 Min. EA 9601-06 12/11/10 364-160 (1) These specimens held as 7/91/21 .0835 0835 040 .040 1410 1130 707 7.7 0,8 6.5 7:1 Boulline Think, Mile lent-Up Rete O/Min. dherend Thickness DH3 #7226-13021D-Splice Thickness Specimen No. ID-Care Temp./Fine Ah. Betch/Roll Splice Meterial Upper-Inches Right-Inches Lover-Inches Left-Inches Adhesive T.pe Cure Press, tre Quality Assur Upper Right LOVER RIGHT Upper Left Lower Lett. Papel Ident. Lay-Up Date Lay-Up Time Cure Date The Ident. Cure Time NOTES:

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				PROGRAM	PRASE AN	IC DATES	PABRIC.	MONDED JOINT SPECIMENS - FARRICATION AND INSPECTION LOS PROCEAN PRASE AND SPECIMEN INSPECTION NUMBER	S INSPECT	TION LOG	PRASE	₩ .	- CONFIGURATION C	TOM C		
DNO #7226_13021C-	7707	7402	1403	1017	1405	3041	1407	14 08	1409	1410	11/1	1412	1413	1414	1A15	
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Left - Inches	.119	.120	611	.112	.120	.12	.120	611.	.121	6TT:	61.	.121	.120	.121	.120	
Right - Inches	.128		.129	ıει·	.129	.130	.129	127	.129	128	.129	128	.127	.129	.127	
Adbesive Type	EA9601-56	×														
Adb. Batch/Roll	383-5/r															
Lay-Up Time	1330															
Lay-Up Date	17/12/11															
Cure Line	0850		N TH	LDR 412793												
Cure Date	1/22/1															
Cure Pressure	30															
Heat-Up Rate 0/Min.	6.4															
Cure Temp. /Time	260°F/8¢ Min.	Hin.														
Bondline Thick, Mils																
left	6.2	0.9	0*9	6.0	6.2	0.9	6.2	6.0	6.2	5.5	0.9	0.9	6.0	6.2	2.9	
Right	5.7	5.8	5.7	6.0	5.5	6.0	5.7	5.7	6.0	5.0	5.6	5.9	5.3	5.6	5.7	
Inspect	Fabrica	Fabrication impection per drawing performed	ection	er draw	the peri	corned or	7	specimens -	R. J. E	Fradley.						
quelity Assur.	Bond 11n	Bondling thickness, ultrasonic cases and x-ray	188, ult	ason,c	C-BCER &	a -x pu	inspection	ion - R	E. Shupe.	نو						
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### Fig. 2 - FARRICATON AND DISPECTION LOG PRODUCT LINES 111003 1111003 1111004 (Conet.) 111006 1111006 1111005 #### Fig. 2												LOCKI	LOCKHEED-GEORGIA		COMPANY		TABLE AC
1,006 1,002 1,11003 1,11003 1,11004 (Cont.) 1,111004 1,111004 1,111005 1,11002 1,11002 1,11003	BONUED JOINT SPECIMENS - P PROGRAM PRASE AND SPECIMEN	BORUED JOIN PROGRAM PEA	ED JOIN RAM PEA	164 F/	SPICONEL E AND SPI	KEDEN II	CATION CATION	AND INSPI FICH NUM	ECTION D	8	PAAG	H	MOTOURA				
1406 1407 1409 1419 1412 1413 1414 1415 1-085 1-084 - 0.084 - 0.0845 - 0.085 -	south times simos simos simos simos	111DOL 111AGE	311A02	-	111011	Γ.			_	\vdash	(Cont.)	111004	111004	111004	111005	111405	
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10180 .03405 .0390 .0390 .0390 .0395 .0395 .0395 .0396 .0390 .03	.0387 .0592 .0586	•9886	_	읙	•0590	_	┪	-†	┪	-	2650	2850	26504	.0585	40575	0950	
3.8 4.5 4.5 4.5 4.3 4.7 4.3 4.0 4.0 5.0 5.0 5.0 5.0 5.0 5.0 5.0 5.0 5.0 5	80.49.	•0354	-1	ণ	8		ᅥ	_	_		•0390	•0380	•0395	.0385	.0370	•0355	
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492 .504 .505 .512 .517 .520 .495 .498 .502	864*	864*		164.				Г		Ι-		.508	.505	1050	508	•506	
and X-ray inspections - R. J. Bradley	.513 .495 .512 .507 .503	.507		.503		Г		Г	Г	T		.520	.495	864.	88.	500	
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and X-ray itspections - R. E. Shi	429783				П			\parallel		$\ $						A	
and X-ray in special on a - R. E. Shi	Fabrication inspection per drawing per	spection per drawing p	per drawing p	30	F	Ormad	8	╀	1.5	valber							
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Processive Transformer Processive Transfor	TASE AND SPEC (Cont.) 111A		100						***************************************
111.006 111.006 111.007 111.007 111.007 111.005 111.008 111.	(cont.) 111A	DE AND DESPECTI		PRASE	- H	CONFIGURATION	ea 15		
1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1,	1A21 1A22 1A23	11408 111008	111DOR 111C09	(Cont.)	111409	1111007		111010	
1		11/25	1A26 1A27	1428	1429	1430	1431	1A32	
11 T1 T2	0845 .0845 .0845		160. 2480.	•0845	• 0845	-0845	5,180	.085	
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100	.0380 .0380 .0378	}	├	-	·0415	\$0405	÷0+0÷	0140	
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3.8 h.2 h.0 3.7 h.4 5.0 h.2 h.0 b.0 5.501 5.68 5.10 5.11 5.12 5.514 5.16 5.50 1.000 1.000 1.2/18/70	3.8 4.3	_		7.5	3.7	2.4	2.7	3.6	+
2507 5508 5510 5512 5514 5516 5516 5503 14086 14086 14087 14 4 4084 5500 1511 5511 5510 5509 5512 5507 5512 5515 14082 1500 12/18/70 120/18/70 5 6 12/18/70 120/350 12	5.0 4.2		3.9 3.7	7.	3.7	0.7	4.5	0.4.	-
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12/18/70 12/	.512 .507	\vdash	66n° 66n°	.493	.188	.487	.487	.485	
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(9/Nin) 6 120/350 120/350 120/350 Patriotion in per drawing performed on all specimens - R. J. Bondline thickness, ultrasonic C-scan and X-Rry inspections - R. E.									
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428783 428783 Febrication inspection per drawing performed on all specimens - R. E. Bondlibe thickness, ultrasonic C-scan and X-dry inspections - R. E.								Ā	
#20703 Febrication inspection per drawing performed on all specimens - R. J. Bondlike thickness, ultrasonic C-scan and X-Rry inspections - R. E.				-				 	
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		808 175	BONDED JOINT SPECIDENS - PABRICA PROGRAM PRASE AND SPECIDEN LIENT	T SPECI	PECINEN	- PABRICATI	FICH AND INSPECT PERCATION NUMBER	INSPECTION LOW	100		PEASE	I - CONF	- CONFIGURATION 1	æ	
Specimen No. IB -	1511401	SILAOI SILACE	511DO1 511A03	511A03	511404	511D02	\$11A05	·Ω	511107	511408	511003	511409	511410		
DMG #7226-1802TB -	ו אען		1443	ንላቱቱ	1445	37/16	7.447	1448	1 4 #9	1 780	1451	1452	1A53	_	
Composite Thickness	.0845	.0845	.0845	.085	.0855	•085	.0855	%	280.	.083	.83	.083	.083		
Metal Material	11	П	ĪĪ										Ā		
Metal Thickness	Г	Γ	Γ	30.	38.	180	180	180	980	980	.085	180	180.		
Step 1	•058	Γ	Π	8	.05B	.059	938	650	910	910	910	910	910		
Step 2	•036	.037	•036	rio.	.037	.038	.037	.037	.033	•032	1	2000	•032		
step 3		.018	910.	.017	.017	,017	.018	.018	.030	Г		.030	•030		
Bondline Thi se										-					
									5.5		5.5	5.5	5.5		
Step 2										5.9		6.0	6.0		
Step 3									5.5		5.4	5.5	5.5		
Stap Length			-												
Step 1										.507		.505	.511		
Step 2									.487			.500	•506		
Step 3									505	-	.509	.510	.510		
Adiosive / Wt	243601/109643	\$70							12	5.	tt		•		
Batch / Holl	►/461-408	- -						1	383-103/EE				4		
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Layup Date	17/6/5							4	1,/91/2						
Cure Thee	₹#C.	İ	 					4	3045				•		
Cure hate	2/3/71	İ				! ;		Ī	1/161/1				ł		
Cure Freshure	લ	1				i		1	95				•		
Meatup Rate ("F/Min.)			 					1	2.2				F		
Tine/Temp	130/320	1						À	120/350	ļ					
L.D.R. No.	4.27.4	1						4	428276						
Inspection	Fabr. cation inspection	tton 1mg	pection	er ore	er drewing performed	ia	n all mp	nger (mens	- K. J.	Bradley			<u> </u>		
Quality Assur.	Bond 11	Bond Libe thickness, ultrasonic C-scan	ess, ul	rasonic	C-ecan	You X-X pur	y inspections	•	R. E. Stupe	8.			-		
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												LOCK	LOCKHEEDGEORGIA	ORGIA C	LOCKHEEDGEORGIA COMPANY	8	REPORT NO. TABLE AG.	
		F. 5	POSTRAN 1	DINT SIE	CIMENS D SPECIM	FABRICA EN IDEN	TTION AN	BECCHED JOINT SPECIMENS - FABRICATION AND INSPECTION LOF PROCEAM THASE AND SPECIMEN LIBERTIFICATION NUMBER	TON LOT	- R	PRASE I -	CONFIGURATION	WEION B	i				
Profess 10. 18 -	(tost)	112401	112402	112001	112403	112no3 112AO4	112405	112002	(Cont.)	112406	112A07	112408	112103	112407	112A10	(Cont.)		
	_		_	1304	130%	3061	1407	1309	60दा	unio	เลน	1912	1913	1814	1815	1816		
.ouponite : Bickness	980.	88.	8 98	.0%5	980.		\$860*	9885	680	680•	980	.0885	288	,0885	<u>8</u>	:080:		
Watel Material	Alus.											,	-					-7
Metal Thickness	280.	 	ર્જે	.0925	.0825	,082¢	.0825	.0825	.0825	•0825	.0825	.0825	.0825	.0825	.0825	.0825		1
Step 1	Т	939	جۇ.	6,5	655	940.	.059	650	.059	.058	959	.058	•050	.058	.059	.059		
3169 2 (1)	980		1	.035	360.]	.035	.036	•036	.036	.036	.036	•036	•036	•036	.036		
step 3 (1)	510.	.015	210.	.0145	.015	.016	.015	\$10.	310.	.015	.015	.015	.015	.015	.015	,015		7
Bordline Thickness	_		-										 					7
t tep 1	3.4	3.5	9.	3.4	7,7	٥٠	3.2	3.4	3.4	3.6	3.7	3.5	3.5	3.0	3.4	3.3	***************************************	T
2 Jes			7.5	3.5	3.5		3.5	3.5	3.6.	3.9	0.4	3.9	×.	3.6	3.5	,, i.		T
Stap 3	3.6	0.4	0.1	3.5	3.6		3.3	0.4	3.4	0.4	4.0	0.1	3.6	3.4	3.7	3.9		7
top langth																		
itap 1			.510	.512	.513		-515	-510 -	-515	.509	.512	•512	.512	-510-	515.	510		
S dette		-	.513	.508	.508		•508	.508	•209	.509	.510	•510	605.	86	.509	.510		_
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Cure Time -Total/Templ	نہ ا	Q.																-
L.D.?. No.	461214			:		•												
Inspertion	Fabrica	Fabrication inspection	pert lon	per dra	per drawing per		بعا	nil specimens	- P. J.	Bradley						-		
quality Assur.	Pondi	thickbene, ul	zese, ul	trasonic		and X-ray		inspections -	R. E. Shupe	n.pe								1
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					:							A DIVISION	107 LOCKH	ED AIRCRA?	A DIVISION OF LOCKHED AIRCRAFT CORPORATION	Ē	2044		
			e g	ONDED JC	BONDED JOINT SIECTHENS PROGRAM PHASE AND SPEC	DENS -	FABRICA M INENT	FICH AND	- FABRICATION AND INSPECTION LOT	TON LOT	# # # ·	PHASE I -	CONFIGURATION	ATION B					
Specimen No. 15	(Cont.	딝	221402	121001	121403	121AOL	221405	121002	(Cont.	12.1406	ופתפו	121,408	121003	60V121	121410	(cont.)		-	
DMD. 7226-13021B	3401		3403	3404	3405	3406	3407	3 4 08	3409	3410	3411	3412	3413	3414	<u> </u>	34.16	-	 	
Composite Thickness	33	.083	-082	.0825	• 08 3	8	.0825	2 8 85	.0825	.280	.0825	.83	.0835	.0335	:083	3835	-	 -	-
Metal Material		1							1							4		+	
Metal Thickness			180	180.	180.	.0365	580:	5750	:083	.0835	180.	180.	.084.5	.0845	.0825	.0835		+	
Step 1	650.	980	8	.059	0,00	900	•050	980	090	090	•059	090	.059	030	.059	.059	+	+	
Step 2		 :	.038	.038	.038	.038	.038	.038	.039	.039	.038	.038	.038	.038	.038	.038	+	+	
Step 3	710.	019	710.	.018	.018	.015	710.	:018	.017	eto.	010.	110.	910.	710.	910.	.01d	-	+	1
bondline Thickness						!										-	+	+	
Step 1	4.3	7.4	0.1	7.7	0.7	0.4	0.4	4.2	0.4	7:7	0.4	0.1	3.8	0:4	7:7	4.2	+	+	
Stop 2	3.7		3.5	3.7	3.6	3.5	3.6	3.6	3.5	3.9	3.7	3.6	5.7	3.9	3.8	3.7	-	-	
Step 3	3.5	3•6	3.5	3.6	3.6	3.7	3.5	3.7	4.7	3.6	3.5	3.7	3,6	3.6	3.6	3.5	+	+	T
Step Length											!					-		+	
Step 1	.475			.475	.478	.478	.493	.475	264.	264.	:475	824.	364.	01.70	.475	.476	-	+	
Step 2				,50t		.510	.510	.509	364.	661.	.510	.509	.510	-509	.510	.508	-	-	T
Stop 3	55	501	.505	.sœ	.507	.50	.505	.507	84.	864	,505	.507	.507	505	.505	.505		-	
Acusatve / Hts.	LANGOIV.	1.045.															-	+	
Batch / Holl	364-154/\$	+ */			: 												-	+	
Layup Time	0660	H	+					-									+	+	
Layup Date	2/2/11																	+	T
Cure Time	1512																+	-	
Cure fate	111/5/2	 																1	
Cure Pressure	8																	+	T
Heat-up Rate (OF/Min)	 -	 												1			+	+	
Cure Time - Total/Teup	120/366																 	+	
L.D.P. %o.	412795								††								+	-	T
Inspection	Faurica	Faurication inspection	pection	Per dra	ting per	عا	n all sp	ectmens	- R. J.	Bred ley								+	1
Quality Assur.	Bond 11 y	r thickness, ultrasonic	38, u)	rasonic	(-scan	and X-re	10	tions -	R. E. SH	R						}-		+	T
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													LOCK	LOCKHEED. GEORGIA		COMPANY PT CORPORAT		MEPORT MA. TABLE AU	4c
Comp. State Stat				HOOR	AM PHASE	SPECIMES AND SP	KS - FAB	RICATION	AND EAST	PECTION D	99	PEAN		FIGURAT					
1		(Cont.)	211401	211A02	211101	_	211404	211405	(cont.)	200112	: (211408	211203	211409	211410			
1,000, 1	DAG 17226-1302TB	19461	SAOS		5 A 04		5A06	5A07	5408	5409	5410	5411	5412	5A13	5A14	5A15	5.41-,		
1	Composite Thickness	. ode5	.0825	.0825	.083	.083	.083	.083	.033	.083	.83	•083	.083	.0825	.0825	88.	.083		
1.08 2.09	Hatal Material	13															•		_
10 10 10 10 10 10 10 10	Metal Thickness	£	989	980	880	.0875	180:	1881	1.80.	8	380	35.	.0855	.035	.085	.084.5	.0335		-
19 19 19 19 19 19 19 19	3ter 1	650	650	980	.059	.059	•050	.058	.05B	.058	•050	650	.058	650.	.059	.058	.059		-
13.7 13.7 13.7 13.9	Step 2	•	.039	.038	.038	.039	.038	.037	.037	.038	.037	.038	.038	.037	.037	.038	.038		
1,1 1,1	Step 3 (1)	ĺ	610.	910.	610.	610.	610.	610.	6.0.	.019	.019	.019	.019	.019	910.	.019	610.		
3.7 3.7 3.4 3.4 3.5 3.7 3.6 3.6 3.5 3.5 3.5 3.6	1	i .					,												
3.17 3.43 3.16 3.17 4.10 1.15 3.16 3.16 3.16 3.16 3.16 3.17 3.16 3.17 3.16 3.17 3.16 3.17 3.15 3.15 3.15 3.17 3.15 3.15 3.17 3.15 3.15 3.17 3.15 3.17 3.15 3.17 3.15 3.17 3.18 3.17 3.18 3.17 3.18 3.18 3.17 3.18		3.7	3.7	3.7	3.5	3.7	3.8	3.6	3.7	3.6	3.6	3.5	3.5	3.8	3.5	3.5	3.6		
1,000 1,00	Step 2	3.7	3.3	3.3	3.6	3.7	0.4	3.5	3.6	3.6	3.6	3.6	3.7	3.6	3.6	3.8	3.7		_
550 504 508 504 500	Step 3	717	1 16	414	415	414	۳. ۱	3.3	3.8	3.8	7.5	4.2	4.5	0.4	0.1	4.5	4.5		_
550 594 552 594 500 591 590 592 591 590 592 592 593	step ength				,														
180 180	Step 1	.500	.504	.502	.50t	.588	.501	.500	.502	.501	•500	.503	.501	.500	58	-505	2,000		
518 518	Step 2	87	064.	984.	991	8	987.	1.487	884.	1.187	061.	.485	.48>	1997	064.	185	187		
\$14-154 K	Step 3	.518	.518	.519	.518	.516	.518	517	.518	.519	.517	.513	.525	.317	518	.518	518	<u></u>	
2030 2030	Adhesive / Wt	/109013	245																_
275/71 2	Batch / Holl	26-15	7																
1512 275/71 275	Layup Titor	0330	į														4		 -
1512 275/71 200	Layup Date	275/71																	
(9) (9) (1) (2) 3 feet Thereonic 2-som had 3-reg instrictions - R. E. Cirepe (1) (2) 3 feet Thereonic 2-som had 3-reg instrictions - R. E. Cirepe (1) (2) 3 feet Thereonic 2-som had 3-reg instrictions - R. E. Cirepe	Cure Time	1515					: 1												-
130/366 130	Pate	11/5/c					: :												
41/7795 130/360 130/	are freezare	1	ı		:	! [! !											1		-
12795 112795 Fabrication imposition per drawing to formed on all speciment - N. J. Bradley Bondline thickness, ultrasonic fearure N. J. Bradley (1) Cor 3 fertal Thekness (20) former toler nee	Heat Jy Hate (OF/Mir),				. 1		: :							***************************************					-
Fibrication imposition per drawing re-formed on all specimens - N. J. Bradley Fondling thickness, ultrasonic fiscin and A-rey tusp-defous - N. E. Strape (1) Sep 3 Fertal Thickness (2017) over toler nice	Tire Time -Total/Temp		: :				: 1	-											
Hondlife thickness, ultrasonic Team and A-reg luspertions - R. E. Mrape (1) Sep 3 Fetal Dickness COI" over toler nee	L.13.R. 160.	412795											-						-
(1) cop 3 fortal Thekmus COl" over toler nee	1	Fabric	tion in	pection	per dra	1 1 1 3 3 3 1 1 1 1 1 1 1 1 1 1 1 1 1 1	formed	m 611 E	ectmens	12	Bradley			!			-	+	-
(1) %of 3 fetal Thekmus 5001" over toler nee		Bondii	S CHICK	ess, ul	rasonic	3-8chn	y pau	מנ	ttons -	E, 3	ede:						-		-
(1) cop 3 feetal Thekings (99) copr toler noe	!	i	;					; 	1					1			-	· 	-
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Process 19 19 19 19 19 19 19													LOCK A DIVISION	HEED-G	LOCKHEEDGEORGIA C	LOCKHEED-GEORGIA COMPANY A DIVINON OF LOCKHEED AIRCRAFT CORPORATION	MODEL .	TABLE A6	191
11 12 13 13 14 14 15 14 15 15 15 15				BONDED ,	PEASTE A	SCINENS-	HABRICA EN IDEN	FION AND	INSPECT ON NUMBER	507 KO1		PUASE	1	TGURATI	g No				1
2.13 8400 9402 8400 9402 8400 9404 6405 1055 1055 1055 1055 1055 1055 1055 1		311401	3,1402	311:01	311403	(cont.)	311404	311405	311002	311406	311407	(Court.)	٦		211400	10000		-	-
18	OMG #7226-1302 1B	9401	20402	9403	9ACA	9405	908	9AC7		888	0410	1140	0410			Stanto		+	- 1
1. 1. 1. 1. 1. 1. 1. 1.	Composite Thickness	85	•0855	.0855	360.	8,	8	8	2,480	8	ğ	ğ	36.5	e g	1 10	2412	+	+	-
1,009, 1,006, 1,007, 1,097, 1,097, 1,009,	Metal Material	7										//2:	(700)	6	6633	6000		1	- [
1,000 1,00	Wetal Thickness	8	86.	8	8	0375	.0875	88	380	186	ğ	2,00	2,00	60				-	T
1,039 1,039 1,039 1,039 1,040 1,039 1,040 1,039 1,03	Step 1	990.	090.	980	1981	000	030	190	090	80	8 8	090	, og	3 8	3 8	20,		+	Т
1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1,	Step 2	650	.039	620	0,0	.030	040	Otto	030	930	38	300			3	8		-	T
1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1,	Jtep 3	.017	710.	613	210	2,10	à	210	660		600	650	•039	•039	•339	•039			_
4.6 4.1 4.2 4.5 4.7 4.3 3.5 4.3 3.6 4.2 3.6 4.2 3.6 4.2 4.2 4.5	Bondline Thickness								2	010	010.	910.	SIO.	:01G	7.0	910.		+	\top
3.7 1, 10 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	Step 1	7.9	1:1	4.3	4.5	4.7	4.3	3.5	4.3	4.7	3.6	6 4	, ,		,		-	1	\neg
1,12 1,12 1,12 1,12 1,12 1,12 1,12 1,14 1,14 1,15 1,14 1,15 1,14 1,15	Step 2	3.7	0.,	3.9	4.5	0.7	8.	6.4	0	, c	2 2		2		01	~		1	7
339 345 349 354 356 356 356 357 359 357 359 353 357 353	Jtep 3	4.2	C 7	2.4	4.7	5.7	4.2	1 7	1	-	200	2 -	y .	200	7.	0.4		-	7
333 334 334 335 336 336 336 336 336 336 336 336 336 336 336 336 336 336 336 336 336 336 337	tep langth	_					!			2		;	ν. •	0,3	\$:5	3.9		-	7
3373 3370 3367 3368 3368 3373	Step 1	.339	345	.349	.354	.356	360	365	369	1.92	360	896	396	956	,	2,0		-	+
394 393 394 397 396 1400 1402 392 395 397 319 31	Step 2	.373	.37.3	.370	.36.	368	368	19.	375	S	180	3	5	500		.302		-	-
EAGCOL CAS C	step 3	305.	303	304	307	yor	2	3			2	3	555	375	313	•385			_
304-1542	Adhesive /wt	EA9601	2.5		T	265	3	202	345	565	565	397	398	330	330	•39⁴			Н
1512 1512	Ratch / Roll	304-15	100													4		_	
1512 2/5/71 90 90 90 90 90 90 90 9	layur Time	0830														*	-		\vdash
1512	Ayup Date	2/5/71																_	+
90 11/Twap 120/360 412795 Febrication inhpection per drawing performed on all specimens - R. J. Bradley Bordliffer thickness, ultrasonic G-scan And X-Ray inspections - R. E. Shupe	ure Tim	1512																	-
90 1/Temp 7 1/Temp 120/360 412795 Fabrication inspection per drowing performed on all specimens - R. J. Bradley Bordlifte thickness, ultrasonic C-scan and X-Rey inspections - R. E. Sjupe	Ture Date	2/5/71														1		-	Н
1/Temp 120/360 412795 Fabrication inspection per drowing performed on all specimens - R. J. Bradley Bondlife thickness, ultrasonic C-scan and X-Ray inspections - R. E. Sjupe	ure Pressure	8									†† 					7	_		-
A12795 A12795 A02710 inspection per drawing performed on all specimens - R. J. Bradley Bordlife thickbess, ultrasonic C-scan and X-Ray inspections - R. E. Sjupe	(Order 11 Vant / Order)					H										ı	_	-	+-
A12795 A12795 Fabrication inspection per drowing performed on all specimens - R. J. Bradley Bondlife thickness, ultrasonic C-scan and X-Rey inspections - R. E. Sjupe	in Time Then / Then	0,76/001																-	+-
Rebrication inspection per drowing performed on all specimens - R. J. Bradley Bondlife thickness, ultrasonic C-scan and X-Rey inspections - R. E. Sjupe	A 20 A 20 A 20 A 20 A 20 A 20 A 20 A 20	2020														ı	-	L	╁
Fabrication inspection per drawing performed on all specimens - R. J. Bradley Bondillor thickbess, ultrasonic C-scan and X-Ray inspections - R. E. Shupe	evens iros	416795	1														-		┿
Bondlifer thickbess, ultrasonic Gecom and X-Ray inspections - R. E. Shupe	napection	Fabrica	tion in	pect ion	per dra	dug pert	brand of	811	_	В. Ј.	radley			-			- -	-	+
	uality Assur.	Rond 110	thickh	686, ul	rasonic	C-scan	nd X-Rep	1 tasped	•	12	8							-	╌
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				PHASE	MECHANICAL JOINT SPECIMENS PHASE I - CONFIGUATION E	TRUNATIO	•	PABRICATI	TON AND	FABRICATION AND INSPECTION LOG	N LOG									
BOZIE-	1041	1, 22	1403	1404	1405	90 5 1	1407	1408	1409	1410	1,41	1000								
	111001	111401	111A02	51401	111501	111002	•	61. 01	111403	111802	12	1000	27.57	1	27		M17	8141	6147	1420
Papel Identification	0						: •				Т.	(3000)	1	(cont.)	777405	611102	(Cont.)	10011	111303	111405
Adberend Thickness																				
	940.	.047	740.	.0465	.0475	.0475	C'17.	.0475	840	, To	Τ	/110:	200							
let Build (ip	070.	\$690.	.0705	2690	690.	.0695	070.	690	690	7	- jó	5888	050	₽	50402	3	.0465	<u>.</u>	970	770.
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Adherend Thick (in)															
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Cure Time - Start	1540													1	
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Cure Pressire	85														
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Fay Surface Sealant	OT MIS													•	
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Torque Application	30 tn-118													A	
Torque - 30 Min.	30 in-ibs	98												4	
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Number of Shims	7											-	1	1		
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MEDGET NO.
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APPENDIX B

TEST DATA FORMS

The results of mechanical properties testing, both static and fatigue, are tabulated in this Appendix for the joints and their constituent materials. These data records provide material properties, specimen configurations, specimen identification, and test conditions and include all material verification and joint test results derived under this program. This information is included in the following order:

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<u>Table</u>	Contents
B1	Material Verification and Checkout
B2	Support Fixture Checkout
B3-B16	Bonded Joint Tests - Phase I
IIB	Bonded Joint Tests - Phase II
1118	Bonded Joint Tests - Phase III
IVB	Mechanical Joint Tests
VB	Graphite and Glass Joint Tests
VIB	Failure Mode Studies

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	LOCKHEED-GEORGIA COMPANY	A DIVISION OF LOCKHERD AIRCRAFT CORPORATION

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Bondline Trisk. In	ć200.	i	. 2050			.0045	.0050	.0045	.0055	.0040	.0045	.0045	.0055	.0055	.0050	.0045	.0050	.0050	.0055	.0045
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Failure Area - In	.746	.736	.736	:735	.746	.736	.746	.726	.736	.746	.735	.735	.745	.736	.776	.735	.736	.736	.739	.736
Ultimate load																				
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Max. Load . Pounds						1100	1100	1100	1100	2100	1600	1600	1600	1600	2100	2100	2100	1600	1100	2100
Max. Shear																				
Stress - PSI						1500	1500	1500	1500 2	2800 2	2200 2	2200	2200	2200	2900	2503	2900	2200	1500	2900
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LOCKHEED-GEORGIA COMPANY	A DIVISION OF LOCKHERS AIRCRAF" CORPORATION

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MAG. CHEAR CTRESS-531		3,4,5	-3400	00.2	3	<u>ي</u> آ	8	-3400	-2202-	8	8	337	23 2	3 8	3	22.5	ş	230	230	
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COLMY STIPPYEES	- 	,	•		 		- <u> </u>	+	-	+			 ,		-	-	<u> </u> 	<u> </u> 		36
(1.18/18/18 WIQTH) 10-3	372	i		:		351				- -		8			-		! ! 			
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(1) No integra faire, tabt d'acontinuel After 10 evelon	ta Carra	bt 3'nco	ntinue	After 10	Cycles		-	1	<u>s</u> -(5)-	See Note	3 200.5	13121		-		<u> </u>	; -	-	_	
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(4) openimen tested prior to bondline measurement.	prior	o bondl	.19 2043	greaent.			4			-	-									

LOCKHEED-GEORGIA CO	OMPANY	COMPORATION
	-CEORGIA C	HOP LOCKHEED AIRCRAFT C

				emac	TOT CHAMPA I SEATED		SaleSector de	TONE LOS	CANTICERATION A		- IMG. NO. /226-1302IA-1A	1302IA-1	<							
ON MANUEL OF		0001.5	100	400115	51,1005		107116	511402			511405	511406	1140;	51.408	51.A09	511A10	1111008	900111	010111	11,1007
DENTING NO. 1020-1 TOTA	14.5	200	1,140	1452	14115		1,472	1,176	7	-	t —	1432	1437	14112	12121	14128	1403	1461	1,1228	01.41
TYPE OF TSBT	•	STS.	STATIC TRACTILE	311		•			- FATTON	E DEGR	ā	F JOINT	1			•	- STATI	l es 1	CORPRESSION 🛨	
H. T. RANGE OF	55	25	7.5	75.	75	75	%	67/73	ં	11/89	71/12	70/72	11/18	(4)	13	(4)	73	92	73	Æ
SPEC. TEM. RISE																				
DURING TEST %		,					٦,	3	0	2	2	3	0	(4)	٥	3		,		
ADHEREKS MATE.	*		!	_	KTA 8	BORON	09/+450	-				,		1					•	
SITICE PLANE MAT.	•				TETANI	TETANTUM GAL-4	CHINANNEALED	O		-					-			•	1	
ADMISTAE	·			-	1096 VI NO.13 -	0-1096 1	9										,		•	
SPECIMEN DIMENSIONS		!																		
LENOVII - IR.	*			•	NOMEN .	0.81 X.	•		1										1	
AVO. WIDTE - IN.	, 183	8624.	-7/2	980	1,000.	.993	939	37.6.	.85	.978	1,3%	0,60	97.6	.985	.995	.995	.98,	7 3 .	186.	881
OVZRLAN LENGTH - IH.												-								
acis Teri	3	\$1:	.7h	92.	. 7h	٠٦.	•15	.75	•775	.74	.75	1,11	.75	. 14	- 33	.74	72.	7.	.15	77
HIGHT STDE	5::5	Ī	÷:	ų.;•	71.	17.	:75	51.	.75	71.5	.75	.75	.75	.74	.74	.74	٠٦٠	17.	7.1.	.7.
BONDLINE THICK. IN.	,000.	-	85%	.0055	5900.	38	2400.	6100.	.0063	2900	•0063	/ { 583;	0900*	,0055	6900'	.0065	6500*	.0057	.0055	% %
PATLURE STOR	~		. =		æ	١,	a:		æ	æ	×	(3)	R	×	æ	17	1.	R	æ	Adheren
PATIUTA AREA - IN.		15	.:3,	.735	07/.	.735	(1:1:	17.	.:3)	.724	.735	(3)	487.	081.	.736	.735	.732	. 728	.726	.739
U.TIWATE : DAD															İ					
Para POUNDS	011,22	2-130	3580	3510	2630	3500	2 300	2540	21.20	2990	2450	(3)	2440				1:80	4560	7094	4100
VI TIMATE SIEME															1					
I ver contr.	3,00	0001	700(1	သရုံး	3600	008†	4000	3400	2900	4100	3300		3400				5700	6300	6300	558
CTRESC RATIO (R)										1	R . 40.	o t			,	*				
HUX. LOAD POUNDS							1,500	900	1500	ဂ္ဂဝဂ	1500	8	1500	930	1452	910				
MAX. SHEAR STREES C.I.							3000	1100	2000	٠. ۲	2000	1100	2000	1100	2000	2011				
CYCLE HATE - GIM							1300	1550	1775	1500	17.5	1550	1775	1500	,	1750				
FATTONE LIFE																	_ -			
C.C. X 22 10.3							2	2000	5	2000	2	1,8,1	5	2:00	1	44.				
JOINT STAFFIESS		!	1]		-+					
~ :	305(1)	(1)687	(1)248	329(1)	333(1)	330(1)	31.9(2)	337(2)	2.12(2)	उडारहा	299(2)	(3)	320(2)	(3)	(3)	3	333(-)	311(1)	329(1)	333
		-																		
HOTES															1			1		Ţ
() Joint atliffing		on ntails specaren determined from bloge of	-en dote	rained :	ron slog	~!	ord v det	ection	chrve for	2.0	2	•				+				
(2) Jo nt stiffness	on int	on fat gue sprefines dederrined from slope of	inet, det	urnined	from 61c		oad v der	definetion	eurve fo	2.0	gage length.	th.						1		
(1) Philipse occurred in spiles plate during fatigue loading	d in sp	told act	e daring	fat! gua	loading							<u> </u>								
1	optainn	c: ant ;	recorde	ranlfunction	ction								<u> </u>							

(s) specimen failed during intigue cycling, but still qualifies for baseline data list.

CALL TANE B3 LOCKHEED.GEORGIA COMPANY LOININGH UP LOCKHEED ARCHAPT COMPONATION 811114 .0070 72-73 14122 1750 2333 3.760 .746 ĕ \$ 5 7. 811413 8 260 1750 5,00 8 8 :43 1226-1302IA-1A 친 22 .75 .0063 2300 टाभा । 72-73 1514 8 .736 1720 8 8 -75 gage length. 17 9900. SOURCE JOINT TESTS - CONFIGURATION A - DMG. NO. 811411 .746 1790 818 8 170 **1118** 166 ₹. .75 2 c 2.0" 0700. 811110 14120 2500 8 86 8 <u>Ş</u> 9₩2. CYCLE .75 ₹. 13 Б curve 3,700 0 911405 811409 8 101 8 838 8 71-72 8 14114 .739 7 53 i en dedermined from niche of ided vo. deflection .052 3700 241. કૂ ફ 2760 .75 (3) 1**4**241 .75 Ħ SILACL 9500. 88 8 2780 3 .75 5 1423 P œ 81:408 34H(1) 1 370 ٠,500 1400 1625 10.20 e S ٠;٠ :/22 2450 965 17 ₹. 7 ø. 34.1() BILAGI MASE I 2. 82. 340 2450 981 817. 8 107 .713 1439 7. 17. œ + STATIC HELOAD AND PATICUE GAL.-AV ANNEALS 136(:) 8,1406 3500 3500 1650 35.50 1020 30.2 120 1426 155 3 ÷. ORON OO/445 01.0 90-1096 (1)348 (1)348 (1)28 (Eg.(mark m/m/801) Specimen :ailed during static pre-load 811403 5160 £8. ĕ 1030 8 1650 NOWCHA: X 18.0 200 3 **6141** 1.5 ગ ŧ. 2 TITAITIN Joint attirings on atetic spec SPON EN 3 51.5 8,1,100 1 1,100 E TIG 8 1050 8 25. ş : 8: :8: 250 1273 61 811401 5.00 1031 : 8 1,100 ٤,, 3650 6+1. 322 1030 i 17.71 ¥ ANX SHAN STREET DRANTNO NO. 7275-13021A AVC. WINTH - IN. HIGHT SIDE BONDLINE THICK. IN. 2773-25 X 10-3 SPECIALN CIMENTONS SPLACE ELATE MATE . STARK Fea - 131 Ä אנג ירים יאמנים TYCLE RATE - CIM STREET RATTO (84) SPIC. TEMP, RICE PARAMO TEST P LUME STATEMES SPECTACK NO. LA-THE REAL THAT AIMESTYE H. T. RANGE OF ADHERAND MATT. EARTOW: 117E FALLINE AUEN te i route. PAILURE STAE TYPE OF TEST TEST : ODE CONTRACTOR MOTE 3 હ

COMPANY	PT COMPORATIO
LOCKHEED-GEORGIA	A DIVISION C. LOCKHEED AIRCRAFT COMPORATION

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					HLSE I BONDED		JOIN, IESTS		- CONFIGURATION A		.G. NO.	. DWG. NO. 7726-13021A-1A	14-14 14-14						
CPSCIMIN NO. IA-	111/23	111124	111023	111024	111025	111026	11,1821	111922	111823	111324	_	111B26	111827	1.1320	11.1829			1.1B3C	Ì
DRAWING NO. (3021A	เหร	14132	וטערו	791977	1349	บรรช	าะเห	1A124	1374	1,41.	LALES	1A136	IA137	H136	17140	ויואו	14143	141-4	٦
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room testp. Pange ^o p	£1./z1.	72/73	nJ/∞	1.3	73/74	₹1/±£	70/76	15	51/41	73	73	12/13	.13	73	21.	7.5	72	72/73	
CPEC, TEMP, HISE		i																	
4º TEST CHIMO		_ 	n		2	}	2	0	2	3	1	2	2	2	7	-1	62	1	-
	1		-					8-PLY B	BORON 00/	1,50				-				•	٦
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7. (ESTVE	•							- EPON	ЕРОИ ЕА 9601-b6	D6				-•-			٠	1	
SPECIMEN DIMENSIONS																			
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overly: Lerath - III.															-				
LEFT SIDE	.j.,		.75	۰/د	.73	.71.	::	.74	£7.	.75	.74	+7.t+	47.	.74	71.	.7h	.77.	.74	
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BOWLINE THESK, IN.	\ 88 88	0000	ڏ ع	500,00	.050	.005:	,500,	3000.	.0051	07.00.	.0067	1900	-0052	، 0055	0900.	•0000	o:00.	.we3	
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13. 120005																			
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Wide allevel STRIBS-151	1100	8,11	318	-3~00	8	3,,00	8	1.00	ž	1,00	7,00	8	1,100	3	š	1700	2002	7,400	
CYCLE RATE - DPM	्। य	38.1	8	8	8	8	300	8	1500	1200	8	1300	Š	1200	\S	8	8	900	
TILATE LIFE							-								1		1		
COURS X 19-3	11.	3	121	15.:		20.5	200	2.11	3000	8.7	3.25	75.1	6.05	5.	115%	3,7.	36.41	~	
JOHN STEENSS	-	•													-		1		
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				琵	PHASE I BONDED JO	NUED JO:	OINT TESTS	1	CONFIGURATION	4	. }-	> ├ ~	01411				-+
	-			2 Light	S LIAIL.	3 21112	511413 5	5.1414 51		<u>~</u>		211410	2014			-	+
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TO TRUE OF		-	+	+	+			>	BORON OOVERSO	+-		\parallel					
TALESTON NAMED IAI			#	#	#			∮	GAY IN ANTRAIR	MEALED		H	1			-	_
DECKEND PROPERTY		+	+					1					T		1		-
SPLICE. PLATE MATERIAL		++					#	+	50 1006 VI		-	-				+	+
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SITC DEEN DEFENSIONS								NOMINALLY	7	18:0	-	1	13			-	-
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AVG. WIDTH - IN.	100	200	1000 T	126	- 227					1	+	1	+		 		4
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201 P	7		52.	52	77.	#	1	1 2 2	188	.0051	.0055	.0058	.0053				
RICHE THE TANK	4500	88	38	.005B	4500.	33.50	1000	.223		-	æ	æ	æ	-	-		
BONDLINE STAKEN. """.	_	_	**		1	Ľ.	7	1			11.0	730	.748		-		-
FAILURE SAUL	32%	730		.736	147	54L2	-229	1257	127	7						-	-
FATURE AREA - JAA					-		-			-							+
ULTRATE, LOAD			2,160	3500				2160	3210		1				_	+	-
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ULT. STRAR STRESS-PSI	22.5	250	37.7	3				Ĺ	01.0+						_		-
STREES RATIO (R)			01.0		6	8	of Z	1440	.750	88	730	995	122				
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											A 91W	LOCKHEED-GEORGIA COMPANY A DIVISION OF LOCKHEED AIRCRAFT CORPORATION	SEORGIA	COMPANY FT COMPORA	8		MODEL PAGE	TABLE B3	1
				£.	PHAME I BONDED		JOINT TESTS	TANCO -	CONFIGURATION	A - DNG.	€	7226-1302 IA- !A							
SINCIPUM NO. 1A.	703177	77.402	TITEOI	104117	711105	211106	Tryot	80.771	7111102	31110	TILL	:							
DKG. NO. 7226-13021A	LAYEL.	,70%	3444	34.	STIVI -	1463	1402	.30	1451	1462	M133		_		_				
TYPE OF SKOT			LATION		. DLOCK SPRCT	BUM LOAD	136		-	1	•			BLOCK	SPECTRUM	CADING	ETAILS		
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ADBRESHED MATERIAL		-	\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \	BORON OF /+LC	/+۱۳۰۵				X	 		,	2.5	-	-	-	-	S	SX
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RIGHT SIDE	.75	.7.5	η).		_	52.	.75	57.	7.	77.	72.	2	7.0	7	2	 	1 22		v 8
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SATIMBE LOAD IN "4"s	+6	+10	+10	7,4	45	77	7.7	-48-	01+	84	77	91	4	9	4	7	8		
ID. OF CYCLES IN		1						+		1	-	50	4	वार	1	1	7		
LAST LOAD LEVEL	1.25	-25-	-25	156	1743	.25	71	1,2	-25	.25	.25								
		→ :					i	-				NOTES	(1)	A load	of 1g cor	responde	d to	oint sbe	10
COTAL NO. OF CYCLES	- 					_								stress	dr 330 p.				
CXCLES X 103	17,592, 17,631	17.63.71	17.601	17.469	16.446	17.594	12.735	52,800	17.601	17.550	88.010		(2)	Block 2	1	app ted afte	r Block	but to	revera
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				¥.	SE I BON	PHASE I BONDED JOINT	IT TESTS	- COKPIG	CONFIGURATION	A - DHG.	NO. 7226-13021A-1A	A1-			ļ. -	1	
SPECIMEN NO. 1A	TOSTE	70500	711003	405117	202117					21,1010				- 			
1-412011-9221 D.	18153	14155	18157	14160	14165	18773	177	1A172	72.141	14177			REAL	REALISTIC SPECT	SPECTRUM LOADING DETAILS	G DETAILS	
TEAT TO A.		EATIGUE			SPECTR:M 10ADIT	HOVOI V	9	,	1	75 /76		1040			10AD	9	*
H.T. RANGE OF	11	92	75/76	15/76	92	34/12	13/14	0	7	277		M. P. B. F. B.		: _a	(1881)	(8)	(उद्धाः)
SPECTOR RIGHT					1		١,	,		-	+	1		•3.6		875	F.
DURING TEST OF	0		2	+	2	3			1			2	_	-3.2		780	2
ADDREND PATERIAL			- 3 PLY BORON	Т	0.					+		-	_	8.3		680	1.
SPLICE RIATE MATERIAL.			TETANTUM	189	N ANKEALED							-7		4.5.4		585	۳ -
ADEESTYR.			23	90-1096 - V3 JUNES -	8-3				 			٠	-	2.0		186	7
SPECTATE DIMENSIONS					1							4	_	-1.6		390	
LENGTH - IN.				5;;	18.0				188	3			 	.1.2		290	4
AVG. WIDTH - IN.	-1897	-786	807	88	100	1007	201	1001	70017	1	-	60	_	-1.0		24:	2
OVERIAP INNGTH . IN.						1	ī	f	F	11.		٥		8.0		195	
LETT SIDE	-72	17.	12.	-73	-72	7		1	1 1	75		10		4.0-		- 35	٠ -
RIGHT SIDE	135	7.	.75	172	4	15.00	2 6	183	170	88		11		0	-	- 5-	2
HONDLING THICK, IN.	1500	#500°	∞58	558	2583	₹	1	7 :		•		12		1.0	-	245	
PATTURE STOR	В	-	4		e .	•	252		17/2			13		2.56		625	~ -
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PATLIME OCCURRED, DIRLIN	-4_	()	.1.				,	-	-2	-		91		5.0	_i		7
HIBBION TYPE NO.	4	THE PERSON	4		4	-	1	-		 		17		6.0	-	7460	2
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ACTUAL FAILURG													+	+	-i- 		!
LOAD - POUNDS	1910	2010	2160	1700	1720	2120	1700	1910	2180	1300	- -				-	-	1
									-		_		-		1	+	
NOTES: (1) Emiliar opeurred during epolicional londing after (first	occurred.	during.	4,155,190	Tower T	K. after		400 £11gp	group.				+	<u> </u> -			-	-
Tullar	1300 am	occurred in adherend.	perand											-			
(2) This lo	This load layed was added for testing convenience only	188 8.14gd	for te	tink cor	ventence	only				+	-		<u> </u>		 -	: !	
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CH ANDREAS	TR 4 TRVI	
	YNACHED ALGERIAS CENTURES	MANAGEMENT AND ANALYSIS OF TAXABLE AND TAX

				#d	PHA'E I BO	BONDET JOI	JOLNY TEXTS	•	CONFICURATION A		- IMG. NO. 7226-13021A-1B	5-13021A							-
SPECIMEN NO. IA-	113001	113502	113003	₹60£171	113401	113402	1, 2, AO3	113404	113405	ष्ठी	肻.	굸	2	2	_	Ci	112413	11.341.0	+
130214	1802	1809	1317	2251	1301	180	130%	1810	1811	1B14			1	182-	con.	λ)	11	GE	-
		- STATIC TENSILE	TENSILE	-	*					FATIOUE -	٦,		1		П	1	T	10/11	-
B.T. RANCE OF	7.	7,	73	12.	57/69	12/89	12/69	77	2	10/11	22	69/12	13		15,000	2)/0/		77,77	_
SPEC. IEMP. RISE									†	+	1	1.	1,	1	+	1,	~	0	-
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ADMENTAR MATE.	•			-					- P.T. I BOHON 02,+	S CO X	2/		+					1	-
SPLICE PLATE MATE.	+				-				-PLY BOR	-PLY BOHUN 00/+150								1	-
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SPECIALN DUNISHEDIIS					-					1	†		1				T	•	-
LEBATH - 18.	•								NOMINAILY	0.0.	H	#		+-	8	100	410	913	_
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OVERLAP LEMETH - IN.		-		-	-	-	-			+				Ī	;	177	17.	35.	
302 791			42:	-75	-72-	-33	:72	1.3	-13	17.			+			7	1	Ī,	-
HERT SIDE	2,	.75	17.	7.75	17.	17.	1:2	77.	7.	-13-	7	13	1	5500	1 2 2		1,08	1 5	
BOWING WY THICK . TH.	86.7		.0063	05001	.0052	1900	X	:0065	\$25	.0057	: 	-	55.55	8500	2000:	2020	1		-
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FAILMP APEA - IN.?	.733	1.7:9	1,47.	÷η1.	749	51115	(#)	.738	347.	:47.	199	37.	-750		8	35	027		-
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Par source	3010	ઝૂ	2923	2880	-	_	3300					8630					0.77		
ULTIMATE SHEAP				-	-	-	-				1		-				120		
Managa Par . Pas	4130	700	3900	3800	-	-	897					2000	!					•	
S. 1255 BATTO (4)	_				•	#			2	91.0							13.6	186	
MY, 174' PAUM.6	_	_			350	20,11	076	091/1	1200	1470	8:1	8	Š.	3	22.5	813	205	200	1
May Siffan Shekil 183	-		L		138	1000	1300	802	1680	SS	83	2300	8		3	37.57	33		-
CYCLL SATE - CPM					1650	1730	1600	1725	1650	1750	1675	16:25	1650		2	12(2)	Toxo	(9)	+
PATIGON LIST		- -	1	_	- - - - -			1			1			(1)	130	Ş	(2)	15	-
cycles x 10 ⁻³	_			- 	10,03	1910	(2)	2	2	302	2	757	2						 -
JOHN S THURS	i_				+	 			-			213(3)				<u> </u>	321(3(
_01(c:215.HI/H/H-7:6-1)		332 (3) 360 (3)	7 3-1(3)	24.13.2		-	327.37	<u> </u>											
NOTES					-	-	-	_						-	1		1		
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(2) He fatigue fal	10.01	2011	optione	ure, test digionalimen atten 10	W cycles	1	+	1		- -				-	-	-	-		
•		determined .rg	2102	slope of load vs. derlecti	1 V6. del	Si	adrive tor	10.0 E	HISTOR BE	-				1	1	-		1~	-
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SPECTIES NO. 14	10019	2000.19	617003	613400		613403	6134Ch	613405	901619	F13A07	613408	613409	613410	100119	611502	6111003				
DRANTING NO. 7226-33021A 18X03	18X03	1BX07	TTXET	18X01	20Xet	18XOL	1BX05	18X06	тихов	18X09	DXIO	18X12	18X13	1403	1407	11X11			_	
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AVO. WIDTE - IN.	1.017	1.011	666.	1.011	986.	866.	1.006	98.	1.006	186.	1.008	86.	78.1	.975	.977	-975	<u> </u> -	_	-	
OVERLAP LENGTE - IN.							-								Τ.	-	-	-	-	
.trr sm	.73	.7k	.75	:73	.73	.73	.74	.74	.74	.74	47.	.T.	7.	72.	72.	72.		_	_	
RIGHT SIDE	47.4	12.	17.	.75	.7.	42.	47.	.74	4L.	.74	η .	.75	.75	.75	-75	72.	-	 	_	
FORDLINE PRICK, IN.	8. 8.	1200.	38 88	.0077	.0085	9200.	.007B	0800°	*	at	980	7800.	2800	6700.	2	5005	-	- 	-	
ZALURE TIDE	8/PLATE	T	S/PLATE	1	R	æ	1	1		-	æ	æ	æ	13	-	17	-	-	-	
PATLIER AREA - TR. 2		.748		.738	.737	.739	447.	•735	447.	.738	9ħZ.	647.	.753	.722	.723	222	-	-	L	
ULTINATE LOAD																		_	-	
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STRESS PAU - PAI	2097	0011	1,800		2700		2800							2900	2600	2200	-	-	_	
STREES RETTO (R)								+ 0.10					1	┝	-		-	_	-	
MAX. LOAD POUNDS				Ş,	80	950	745	955	855	096	960	98	8%			-	-	-	-	
MAX. SHEAR STRESS -PSI				1300	2001	1300	1000	1300	1150	1300	1150	1300	3200		-			_	_	
CYCLE BATE - CPM				3400	1600	1750	1550	1800	1800	1775	1600	1750	1650					-	<u> </u>	
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CYCLES & 10-3				46	12210	20	5290	45	85	og g	130	92	91	<u> </u>		-	-	-	-	Γ
JOIN BUILDINGS							_										-	-	-	
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134 (2) 333 (2) 230 (2) influre occurry on this speaken. c. static speaken determined from slope of load vs. deflection curve for 2.0"	
fallire occurre on this specimen.	
Notice place (milling occurre) on this speciment.	
A splite plate inflice occurre on the specimen. Joint stiffness on static specimens determined from sippe of lead vs. deflection curve for 2.00	
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				, a.	PRASE I	BONDEY JOINT TESTS	DET TEST	S - CUNF	- CUNFICURATION A - DWG. NO. 7226-1302IA-5B	(A - DWG	. No. 72	26-1322	CA-5B				
SPECIMEN NO. IA	213001	213002	21,3003	213401	213402	213, 1,	213404	213A05	213406	213A07 2	213408	213A09	213A10		L		
DRAWING NO. [365-1A	5803	5807						Н		_		5B12	5813				
TYPE OF THEIR	←- STAT	- STATIC TESCILE	1.2			FAT.	-	LY STACKING EFFICIE	NO EFFEC	12			•				
R.T. RAKOE OP	11	73	73	73/75	:1/eL	. 69	~	11/69	69	69/19	02	70/71	69				
SPEC. TEMP. RISE										_							
DURIDIO TEST OF	٥	٥	0	2	7	0	1	3	0	2	2	3	0		 		
ADRESION MATE.	↓					H-PLY	PLY BORON +4	+ 00/05#							 		
SPLICE PLATE MATE.	↓					-PLY BORON	71	100%			 	li	1				
ADMESTVE	↓					- EPON E	30 -1096 N	9				H	1				
SPECTATE DIMENSIONS										 	\mid				-		
LICHOTH - IN.	↓					- MCATE	MLLY 1810						•	_	-		
AVG. WIDTH - IN.	1.003	.999	1.007	1,009	1.001	1.006	1.002	1.83	1.0	1.000	1.007	1.012	1.000	_			
OVERLAP LENGTH - IN.									-	-				<u> </u>			
LEFT SIDE	92.	.75	\$,•	91.	92.	276	.76	.76	92.	55.	.76	.76	.76		_		
RICHT SIDE	.74	.74	()	ηL.	.74	.7%	.75	٠74	-75	.75	-75	5:	٠٢.		_		
BONDLINE THICK, IN.	.0057	,0057	.0052	,0057	.0057	.0057	.0055	.0057	0500	7500.	900.	.0050	.0050		_		
FALLURE SIDE	o.	7	7	R	æ	Я	Я	В	ı	R	Я	æ	11				
FALLUNE AREA - IN. 2	247.	.749	.765	747.	.743	.744	.751	.742	.763	.750	.755	.759	.760		_		
ULTINATE LOAD																	
Psu Pothos	2700	2560	2370												 		
ULTIMATE SHEAR																	
STREES Fau - Pai	3600	3400	3100							_							
STRESS RATIO (R)				•		-	- +0.10	+			-				_		
MAX, LOAD POUNDS				955	1040		1200	965	1200	975	1210	283	1180		_		
MAY, SHEAR STREES-PST				1300	00ητ	1600	1600	7300	3600	1300	\vdash	1300	2600		_		
CYCLE PATE - CEM					1600	1675	1800	1500	-1	1700	1800	1800	1650				Γ
FATIGUE LIFE	_																
CYCLES X 10-3				438	170	17	36	2550	191	172	25	120	8				
JOINT STIFFMESS															 		
(13S/IN/IN WIDIN)10"3	337,13	330(1)	717(1)														
					1		+	1	+	1	+	1	_		_		
HOTES:				1	1	T	+	-	-	+	+		+	+	-	1	T
(1) Joint stiffness on static spetimens determined	as on st	tic spe	Inens de		from 810De	5	084 VS. A	deflection curve	•	for 2.0"	gaite len	length.	-		-		
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SPEC PERN NO. I.A. SAUDOR SAUDO	93 21UDQ. 1 'ALT' 7''	11DOL (311.00), (3.11DO),		Z	1 2 1-	RATION A	- 41G. NO.		A2-A13021A-54						
21 1001 21 1002	21 'ALT' 7' 7' 2 '020		·	,	ļ										
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76 "; 76 "; 779 '920 379		┩ ┑╌ ╒┋╌ ┩╌╍┋╌┩╂┈┦ ╏╸┋╘┈╎╸ ┩ ╏┈╽	•	5M5	5A16 5	5A18 5	5A19 5A20	2482	5424	5426	7875	5826		1	
76 :; 279 .980 279 .980 2170 .77.		╶┍┋╍┪┈╍┋╍┩╂┈┩ ┇ ╶┋ ┇┷╌╬╌╂┼┼┼┼	-	-	-#	TAKE	ATIGUE PLX	PLY STACKING	-		#	ļ			
279. 3840 279. 3840 304. 174. 1.1. 174.		╼╼┧╌╍┋╍┪╂┈╢╂╴╌┋╅┈╌╁╴┨╏┈╌┼┈	_	. 52781	10/11	69/89	"1 10/m	11/01. 11/	07/69 1.	38	1:70:-	•			Ì
279. 3850 279. 3850 2170. 177. 1.18. 1.17. 1.18. 1.17. 2170. 1.160			_	i			-		;						į
279 - 920 279 - 920 270 - 176 1.24 - 177 2170 - 1.60		╼┩╂┈┩╌╶┩╅┈╌┧┦┈┼┈	•	9	1	٥	~	2	2	٥	3	0			
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				NA.	PWASE I BON	BONDED JOINT TEXTS	IT TEXTS	- CONFIG	- CONFIGURATION A		- DWG. NO. 7226-13021A-9B &	-1302IA-	26 ¥ 86.						
SPECIMEN NO. IA	313001	313002	131303	313401	313402	3:3403	31 3AOL	313405	313406	31 3A07	312001 312102	_	312503	312A0:	312A02	3.2A03	312AO4	312A05	
[4881A	2046						9805	9807	80g6	9810	2006	4006	2006	97:01	9003	\$006	900′	ROCK	
1	♣ STAT	TENSILE	31		7.4	PATICUE-LA	P LENOTE	EFFECTS		•	TALS -	STATE TENSI	3	14 —— ¥	VIIGUE-I	P LENGTE	EFFECT		
o.	75	75		71/12	69	7.1	72	71/12	12/69	(2)	42.	75	75	71/19	15/14	71/73	71/15	11/14	
SPEC. TEMP. RISE		ĺ																	
DURING TEST OF	0	٥	0	0	c	٥	0	-	-	(2)	٥	0	٥	-	0	7	2	2	
		- :							B-PL! B	BORON OO/	12°							1	
SPLISE PLACE PAIL.	•	-		?-R	A-ALY BORON	00/±459				•	•			LUMINUM	7075-76			1	
AMMINE	ļ								EPON	-1096 kg	90							1	
SPECIMEN DEPENSIONS																			
LENOTH - IN.	↓								NOME	NOMINALLY 14.0	0.							1	
AVC. WIDTH - IN.	1,00	.0371	- - :	1.007	1.00.1	1.003	300,1	1.007	.977	1.003	.976	.983	300	980	386.	996	.981	066-	
OVERLAS LENSTH III.		1	-																
aois agai	ŝ	15.	Ŗ.	.51	.51	.50	.51	.51	٠,	3.	64.	64.	64,	64.	611.	Š	64.	14.	
RICHT SIDE	٥,٠	•50	6۲۰	•50	64.	64.	64.	64.	.50	64.	64.	64,	.50	64.	.50		.50	.20	
SONDLINE THICK. IN.	1500	.0053	0500	,00u7	.0050	.005	.0051	7,00,	•0056	.0053	9₹00.	.0045	.00 ⁴ 6	•0045	11,00	200 200 200 200	.0041	5.5 2.5 2.5 2.5 2.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3.5 3	
FAILURE SIDE	æ	1	L	IJ	1.	I,	н	7	æ	×	×	1	B	-1	1	Ξ	-1	(1)	
TALLINE AREA - III.	104.	.514	454	.514	द्यंद.	.502	.493	.514	604.	164.	.479	, tud2	8,7	.480	.403	Ξ	.481	(1)	
ULTEMATE LOAD												1				_			1
Per: POUNCS	2230	3050	0645								3090	3020	2650						
ULTIPATE SHEAR																			
STRESS I ou - Pet	00;	5200	5000					j			6500	0330	5400						
STREES RATIO (R)			 	↓		₩ . +0.1	0			1	_			↓	ž.	+0.10		1	
STAND GAOL .XXX				910	82.	6,30	869	<u>8</u>	8	89			7	670	3	38 6	670	999	
Max, Shear Street 181				1200	17.00	11.00	1:00	1300	1400	140		· - + 	-	807:	1400	1,00	1400	1400	
CYCLE PATE - 318				152.	14.75	0031	1475	1600	3600	1450				1700	2 FQ	3,00	202.1	1600	
FATIJUS CIPE				_	-							- 			_ _				
CYCLES X 10-3				 							-			130	æ	733	110	3,0	
COINT CITETURES	4	-		7	2	201	565	P	RAD	73					- † -	1			
(1)/ (1)/((6)(13	253(3)								246(3)	262(3)	251(3)						
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(2) No sansaments plate plates of mence on this	to smith	THE EAST	n sute	Teatrad												1			
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	;			787	PHASE I DONDED JOINT TESTS	10E Q301	n Tests	olance -	CONFIGURATION A		- IMG, NO. 7226-13021A-9A	5-1302IA	¥6-		
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Section 18. 1. String Singe													LOCKH	LOCKHEED-GEORGIA COMPANY	MPANY	SCORE TABLE BIO	930
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LOCKHEED.GEORGIA COMPANY A DIVINOM OF LOCKHEED AIRCRAFT COMPOSTION

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***************************************		SPECIMEN NO. IB	DOAMING NO. 7226-130218 1804	TYPE OF TEST	H.T. RANCE TY	SFEC. TEMP. RISE	DUNING TEST OF	ACHEREND WATERLAL 1	ACHEREND NATERIAL 2	ADRESTYR	SPECING DIMERSIONS	iznom - m.	AVC, WIDTH . 18.	ä.	TRICK - Di.		2				Yeu Pounds	ULTINATE SHEAR	7	STRESS RATIO (R)	MX. LOAD FOUNDS	MAX. SHEAR STRESS-PSI	CYCLE RATE: - CPM	FATIGUE LIPE	CYCLES X10-3	JOINT STIPPNESS	(LES/NI/NI/NI)10-5		NOTE:			

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MODEL TABLE BL1 LOCKHEED-GEORGIA COMPANY A BIVINEM OF LOCKHEED AIRCRAFT COMPORATION IZMO 200-1 1100 .0038 •0036 1,46 S 8 1800 7226-1302 IB-34 121409 3 72/75 1.002 .0039 34.1 JALA BALL 889 3300 113 783 3412 1.002 0,000 •0036 .0037 Š 0 1 1 8 0 1 8 0 1 1750 94.1 DAG. 121407 3406 JAV. BASELINE DATA 0400 100.1 7500. .0035 91.1 8 8 5221 3. 535 PHASE I BOLLED JOINTS CONTIGURATION B 3407 3410 1700 .0036 1.002 •0039 2650 88 ನ GAL-MY ANTOCATED 16-PLY BORON 07/900 — 1.001 0400 .0035 9500. 2360 1,00 1775 520 EPON EA 9601... 045 18.0 121AO4 3AO6 300 otor .0035 .0037 2650 1.47 1800 1800 89 NOMINATEX TITAMITE 121ACE 121A03 9 .0036 1.46 74/75 80 1330 1,46 1750 3405 803 3 89/99 .0035 .0035 3403 1.001 5610 1.45 8 1725 IN BURUN ADREAGID. ಜ್ಞ 1.000 .0042 .0036 .0037 2000 1400 1900 3402 223 121003 .0036 1.001 .0038 3 1.47 4820 3300 585 - STATIC TENETLE -OCCURRED OCCURRED 121002 .3037 .00. 20. 36. 36. 1.001 3 38 3408 క్ల 554 FAILURE 1511001 1,000 170 DRAWING NO. 7226-130211 3ACH .0037 £4. : 09517 3700 8 • 1.03/IN/IN WIDTH)10-3 MAX. SHEAR STRESS-FSI BONDLINE TRICK. - IN. WERIAP LENOTH - IN. SPECTION DESCRIONS . AVG. WIDTE - IN. ADPEREND MATERIAL ADRESEND MATERIAL FATURE AREA - IN. JTHESS Fau - Pat DURING TEST OF MAX. LOAD POUNDS YOUR RATE - CPM SPEC. TEMP. RISK STPESS RATIO (R) 1..T. RANGE OF JOINT STIPPIESS SPECIFICAL NO. 13 CYCLES X10-3 LENGTH - IN. ULTDATE SEEAR JULINATE LOAD Pau Pounds TYPE OF TEST FATIGUE LIFE i STEP 1 STEP 2 STEP 3 ADEESTVE

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	SPECIDEN NO. IB	1,-	TYPE OF TEST	R.T. PANCE OF	SPEC. TEMP. RISE	DURING TEST OF	ADBEREND MATERIAL 1	ADTEREND MATCHEAL 2	İ	SPECIMEN DIMENSIONS	LENOTE - IN.	AVG. WIDTH . IN.	OVERTAP LENGTH . IN.		STEP 1	अरक्ष २	STEP 3	PAILURE TREA - IN.	ULTERATE LOAD	Pau Y MOS	UCTINATE SEEAR	STRESS Feu - Pet	STRESS RATIO (R)	MAX, LOAD POUNDS	KAX. SEEAR STRESS.PST	CYCLE RATE - CPN	FATIOUR LIFE	CYCLES XIO ⁻³	COURT SETTERESS	LBS/IN/IN WIDTR 110-3			- E+			

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LOCKHEED-GEORGIA	A DIVISION OF LOCKHEED AIRCRAF

MENORT NO. TABLE BL3

311AM 311A09 311A10 2400 . 033 1.001 73/74 1820 1500 1800 77.7 9415 25 7226-1302TB-9A 0036 2420 2450 1.100 12/69 885 77.7 155 ,00° 5400 1.14 1.14 64/75 1100 3420 1250 3412 PHASE I BONDED JOINTS CONFIGURATION B - DMG. NO. 311A06 311AC .0036 35. 5003 70/73 1.001 1600 1730 1810 1.13 910 11.13 5879 428 7400. .0035 11/11 .00 1,240 88 1.13 1.13 TITANIA GALAV ANNEALED strength FATIOUE - LAP LENGTH EFFECTS 1.12 311AO4 311A05 69/89 .0042 7400 00/12.5°-1.001 991 1650 1.12 179 9 EPON 44-9601-1045 residual NOMINALIY 18.6 .0043 .0042 .0038 72/75 2 5 16-PLY BORON 1100 1220 1.1 1775 8, 1.11 **8**406 324 30 specimens tested for MIAOR MIAO3 1.000 2400° .0045 243 11/01 41/85 1.10 1700 ₹ **8** 8 કુ 55 :100 0400 0400 1.001 3800 (T) 576 3500 883 02:1 1.10 300 86 33.1401 1,000 85. 85. 300. 2400 ₹ 9 4.500 12/69 1.10 1.10 4920 2420 9401 550 g EOOTH: 0015 1.14 1.001 (1) - No fatigue failure, test discontinued 5340 1,700 "A. Failure occurred in boros adherabil..... ğ 8 - STATIC TENSILE -78 1100 311000 5000 1000 1000 1000 8 7200 5110 9408 1.13 585 P 7 313001 1.10 2700 5,000 DRAWING NO. 7226.3 30248 9A03 .9% 1.19 2320 623 MAX. SHEAR STRESS-PSI (125/IN/IN WIDTH)10"3 OVZRIAP LENGTH - IN. SPECINEN DIMENSIONS JTRESS Fau - Pat FAILURE AREA - IN. AVC. WIDTH - IN. NOWDERNE TRICK. -ADEEREND MATERIAL ADBEREND MATERIAL HAX. LOAD POUNDS CYC'E RATE - CPM STRESS RATIO (R) SPEC. TEMP. RISE DURING TEST OF JOINT STIPPICES H.T. RANGE OF CYCLES X10-J SPECIDIEN NO. 13 ULT LIMATE SEEAR LENOTE - IN. ULTRATE LOAD Pau Polness FATIGUE LIFE TYPE OF TEST ores 2 ADRESIVE STEP 3

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BOIDED ANEA - IN.			1.20	13:	1.18	1.22	1.23	.17	.23	1.22	1.23	1.19	22'					
NO. BORDLINE PETCK IN	9900	9500.	980	900	9900	1900'	.0061	.0058	6500*	0900	0900*	.0059	0900					
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TOAB . POLIEDA	•	•	•	•	•	•	•	•	•	. 1	1000	2000	200					
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CYCLE NATE - CPH	1600	1500	1600	Q	1550	001/1	1550	1350	909	1350	•		•		-			
PATIOUE LIFE																		
CYCLES X 10"3	98	18	5	175	8	125	91	169	5	809	•	•			-			
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7	DIVITI E	345		17/01		B						1,991		1.76/.74	77./91.	0.7/0.8	1	64.1		•		-		2530	700	1775		8		3							
- DMG. NO. 7226-1302ID-1A	96 111409	100		72		3				_		066•		4 .76/.12		0 7.0/6.2	R (D (L L	1.50		•		-		2530	1700	1300		2:5		•	_	ARE GIVEN.					_
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ENTA.	111/0	104		69		3 1	8 PLY BORON O	TITANTUM	EPON EA		MONTHLY 18.0	8.		.771.75	77.78	7.7/6.5	د	1.50		•		•		2250 1		1900		62		•		NOT OCCU	£			OT 07 RX	-
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	SPECIDEN NO.	DMC. NO. 7226-1302IE	THE OF THE	R.T. RANDE	SPEC. TROP NISE	DUNING TEST OF	ADMERICAD MATL.	SPLICE PLATE MATE	ADDRESTVE	SPINCIDEN DISCUSIONS	LENOTE - IN.	AWG. WIDTH	WELLAP LEMETE	SUIS TASI	ACIE TIOL	OME SAN THEEK.	PAILER SIDE	FAILUSA: AREA	MEDNAE, 10AD	PRU CUIDE	DISTORES SERVE	STAZBS FAX	STRABS GATTO (A)	MX. toub roums	ALX. URL." STRENG-131	CHUIL RATE	ASTUNE LIPE.	CYCLES , 10"	JOINT STAFFEES	128/11/73 V COTE)10-3							

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				PRACE	PHACE I BOADED JOINT	THEOR OF	TESTS -	COMPIGURATION D		. DNG. NO. 7226-1302TD-18	. 7226.1	30210-11						
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			1	Ť / Ť	11. / 71.	44. July	74/ 73	74/.74	74/.74	.73/.74	147.2	152.77	25/25	+	+	+		
1675 STA			-	7	-	_	•	_				76/.77	27.77	1	-	1	1	
1107 51DS	1-101-101	******						270	_	0 70	_		5.9/6.3			-		
NORDITAL TRUCK, DI.	5.8/4.5 0.3/5.3 9.2/9.4 v.3/8.2	95.29	09/2	805747	8,2/5,8	5.8/5.5	9.575.6	17/0°-	13/02 13/17	11/22 11/22			R1/18					
THE SECT	(8)		3	1					7		Г	53 5	18.1	-				
PATLINE ANEA - IN.	•	•	•	1:21	1.51	7.8	1.55	2:23	N.	55.3	Τ		-	-				
UNITEDATE LAND										1			1	+		_		L
Pan Pompe	8228	3525	8675	•	•	•	·	•	•	•	•	•	+	+	-	-		L
INTERNATE RIBAR	!-									1			+	+	-	-		L
Date Date	6,3	62,5	2005			•			-	1	1	-	1	1	+	+		L
OFFERSA RAPTO (R)	T	1				R = +0.	10						+	+	+	+	1	L
ALV CARG BOUNDS				2070	2520	1920	2650	200	2830	7	7	T	2850	†	+	+		Ļ
MAY AMEAN STREETS, VOIL	1			1100	1700	1300	1800	1400	280	7	1	7	2800	†	$\frac{1}{1}$	+	1	ļ
CYCLE RATE CPH	•	•	•	1725	1750	1800	1800	17775	1775	1750	1800	280	1800	†	+	+		1
PASTOKE LITE										T	1		+	+	-	+		L
CYCLES X10	•	•		58	116	933	23	1030	779	9836	165	957	0		-	-		L
SOUR STUTIESS													+	+	-	-	_	L
CL(REGIN NZ/NZ/SEL)	853	.88.	909	•	·	•		1		1	T	•	-	-	-	-	-	-
3.3 (L. 74 (the Minnesse William 1/4) and some													+	+	+	-	-	L
6	TEMPERA	DOTE STOOL	TO DUE 1	DE PALETY	CTION O	RECORD.	DIO EQUIPMENT.	EF.					1	+				L
8 mW	"I S TU" IN PALLUNE MCHES REPRIN TO "LOURS" & "UPPER" S	True M	SEB RET	7. O. E.	FER" &	JPPER"	PLICE PLATES.	ATES.					+	1	+	+	 -	\downarrow
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												A BITING	AVISION OF LOCKHEED AIRCR		IF COMPORATI	į	<u> </u>	PAGE	THIS	
					=	PEASE 11	- BONDED	BONDED JOINTS CONFIGURATION	OFFICUR	<	- DAG . NC	NO. 7226-1302IIA-1A	302IIA_1	<						
SPECIDACI NO. 11A	11001	11002	1,1003	11007	11004	11005	11006	11401	11402	11403	21103	11A05	31406	11407	22.404	11409	11/10	11001	11002	11003
DING NO. 7226-130211A	T	7777	227	1433	1404	1M5	1425	1,403	1405	1411	1413	1A30	1418	1420	1423	1432	1428	7406	1408	9747
TITE OF TRUE	- STATE	- FEATE-TENSIS		•	STATIC -C	TC COMP	ᅽ			L PA		и жита	DATA -							
R.T. PANCE OF	72	74	72	•	73	72	72	72	62/42	72	72/73	71.	75/80	72	91/72	73/74	71.	67/10	11/99	11
SPEC. TEMP. NISE																				
DUNING TEST OF								2	7	٥	7	٥	3	2	<u>-</u>	-	~	5	7	-
ADREACTO WATE.						ध्यत्र ८ न	BORON	57 2/0												
SPLICE PLACE MATL.						TITAL	BIUM GAL	TAV AMMEALED	- QXIV											
ADIESIVE						EPO T	EA 9601	90.				-								
SPECTOR DESCRIPTIONS																				
LENGTH - IN.	•					THOM —	ALLY 18	; 0					•		;					
AVG. WIDTH - IN.	3,00	3.002	3.006	3.008	3.002	3,002	3.004	3.004	3.005	3.005	3.011	3.008	3,00.5	3.002	3.005	3.006	3.005	3.005	3.001	9.8 8
OVICELAP LENOTES - TN.	 																			
. 1277 STDE	2	47.	1/2	.75	7.	.75	4.	η.·	7.	4L.	.75	.75	47.	.7t	.75		. 7t	÷.7	. 7.	72.
RICHT SIDE	1:	17.	₹.	47.	.75	72.	.75	.75	.75	72.	.73	٠./4	.75	.74	.73	:73	£.	72.	.35	:73
BONDLING THIER. IM.	.0050	3588:	.0050	6 <u>8</u> 8.	4500.	1500:	.0055	.0050	9500*	.0057	.0050	.∞51	9500.	.0055	3,000	:005	4.700	.0053	1500	8
PAISURE SIDE	æ	E	-1		2	3	£	H	ı	æ	æ	7	æ		1	1	1	æ	13	1
PAILURE AREA - IK.	12.25		2.22		2.25			2.25	2,22	2.22	2.20	2.26	2.25	2.25	2.25	2.3 S	2.33	2.55	2.25	2.2
UNITED WITE TOWN																				j
Pau Poutidis	800	11200	11100	3	880	899 899	8	أ												_
ULTDATE SIEAR																				
STREES Fou - Pat	3600	2000	\$000	:	\$000	3000	4100													
JINESS RATIO (R)												÷ =	1.10						7	0.0
MAX. LOAD POINTOS								3110	0t45	3110	2420	3120	2440	3110	2410	3070	2440	7799	7660	999
HAX. SIEAR STRESH-PSI								14:00	1100	1400	1100	1400	1100	140	7100	1400	1100	-2100	8 7	902
CYCLE PATE - CPM	_							1750	1625	1800	1675	1720	1775	1800	1600	1800	1750	1200	1200	250
PATIOUS LIFE	_				_	-														
cycles x10-3	_							89	7.13	7	346	45	1185	92	345	13	87	33.5	22	12.5
JOINT STITTMESS																-				
C.P.J. IN WIDTH 110"	332	328	332		236	227	30				:									
	_					<u> </u>				_										
NOTE .	PATIUME OCCURRED T	CURRED 1	N ADBERTAND.	e.	-	_			-				<u> </u>	<u> </u>						-
:	SPECIDEN HADOT NOT TESTED! WILL HE USED FOR STRAIN SURVEY	LABO7 K	T TEOTE	HILL I	CASO TO	NOR STRA	AN SURVE	8	POELAST	PROTOELASTIC STUDY				-						
•	THESE SPEC	DENS VE	RE DEGRA	ISE SPECIMENS WHE DEGRADATION SPECIMENS THAT	SPEC IMEN	S TRAT B	BAD FAILE	8	REFORE	THEREFORE SUBSTITUTED	ED AS BA	SELINE	DATA TESTS.	.s.						
				L		L				L		L								<u>.</u>
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												TOO'S	LOCKHEED-GEORGIA	ORCIAC	COMPANY		. 1		TABLE ITEM	ã
												A DIVIDED.	PP LOCKHE	10 AMCRAP	a divinde of Locafed angrapt composition				im 2	
				PKASE	11 - 80	COC CENT	PRASE II - BONDKO JOINT TESTS		- CONTIGURATION	A - DWG.	ě	7226_1302IIA.IA & 1C	IA-1A &	21						
SPICEOGR NO. 11A	11006	11005	12001	12002	12003	12401	12402	12403	1240h	12A05	21401	21A0e	21A05	11406	11408	22A01	22A02	22403	22404	22405
DMG. No. 7226-130811A	T	I ~	1003	1008	1014	1001	1004	3000	1009	1012	14 02	1410	3828	1412	1421	3005	1007	1010	1011	101
T173 OF 1357	PATICUE		STATE OF THE	STATES -TENSIEE -	3	- PATIC	CHE-BASEITHE DATA	THE DATA		1				- PATIC	UK DEGR	DATION -				
R.T. RANGE OF	72/75	•	7.6	72	72	73	71/15	74/75	92	74/16	73/75	73/14	73/74	15/14	75	7.4	74	75/76	75	12
SPEC. TRP. RISE																				
PURITY TREE OF	5		•	•	•	2	1	1	0	2	2	0	1	2	0	0	٥	9	٥	ا
ADMINISTON MATE.						ž	MONON O	2,50												
SPLICE PLATE MAPL.	T. GALLOV. ANN	V. AM			₩ 	AD CH	7075-r6 —	j		•	-tit.	GALLAY	AMERIKE			TIV —	ALLINCTION 70/75-TG	- 52-20		
ADMIESTVE						KPOR	EA 9601	90.												
SPECIMEN DIMENSIONS																				
1500TH - DI.						- NONTINALLY	ALLX	18.0 -												
AVG. WIDTE . IR.	3.003	3.004	3.005	3.005	2.256	3.005	3.006	3.005	3.004	3.008	3.003	3.006	3.005	3.005	3.005	3.006	3.008	3.003	3.00	9001
OVERLAP LENGTS - IN.																				
. LEPT SIDE	51.5	. 15	.76	.75	.74	.75	.75	.76	£.	1,1	72.	.75	.75	-75	.75	-75	12	-76	Į.	ř.
RIGHT SIDE	41.	.75	• 16	.76	.75	.75	.75	4L.	.75	.75	.75	.7t	4۲۰	¥.	*	.75	57.	92.	52.	5
BUNDLINE TRICK, IN.	7500,	9500.	1500°	€\$00*	\$400.	.0051	.0051	6400	.0057	0500*	7400.	•0056	.0055	.0051	6400.	.0053	.0050	.0053	6400.	0500
PAILURE SIDE	æ	7	æ	æ	7	ac,	æ	æ	R	×	Я	1	æ	ж	13	æ	æ	æ	æ	æ
FAILURE AREA - IN.	2.22	2.25	2.28	2.28	1.67	2.25	2.25	2.23	2.25	92.5	2.25	2.25	2.22	2.25	2.25	2.25	2.20	2.28	2.38	2.8
ULTOWIE LOAD																				
Pau POUNDS			9090	840	6540						0087	0409		900	5300	8 8	2,50	7540	5980	3 8
ULTHATE BAKAR										_										
STATES Fou - Pet			2700	2900	3900						3500	2700		4100	2400	4200	2500	3300	\$60	350
STICES INTIO (N)	R - +100-	0									H - +.1									
	Г	4725				2920	2920	2890	2890	2890	ं १५७	ं क्षि	2440	2440	2440	2930	2860	2960	2900	2900
HAX. Seea r <i>b</i> taess - P	- PSI-2100	-5100				1300	1300	1300	1300	1300	∞ιι	1100	2100	1100	1100	1300	1300	1300	130c	1300
CYCLE NATE - CIM	1200	1200				1775	1800	1750	1800	1775	1625	1800	1700	1750	1800	1775	1750	1775	1775	1650
PATIOUS LIPS																				
cycles alo ⁻³	35.9	9.6				59	73	36	5	29	300	8	82	88	88	2	5	2	5	2
SOTHE STIFFESS																	-	_	-	j
(186/IN/IN WIDEN)10"3			568	310	Ē						323	327	ğ	350	287	305	ğ	325	316	70
																		_		
																		-		
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									·	; ; -						_		_	_	
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EILA 1A02 1A092 - FARTORE-MALLA - FARTORE-MALLA - B.FLIZ EGRAM - B.FLIZ EGRAM - TYNAMUM - 6A - EFON EA 9601 OMS - NOMINALLY 16 N. 3.004 3.007 IM0056 .0056 III0056 .0056 III0056 2.23										a bivider of Lockhely aircraft Colforation			PAGE	7 707 7
2 14001 41002 1407 1409 - FAFTG EL-NEALLY Th/TT TT Th/TT TT - Bafty Ending - Eigh EA 9601 - HOHINLLY 18 3.004 3.007 17 14 17 17 10 17 10 1056 1. R		PHASE II	- BOKDED	JOINT TESTS	- CONFIGURATION	1 <	- DMG. NO.	7226_13021A_1A	AL-AI					
2 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	41003	41004	\$100 \$											
2 1 2 1 2 1 2 1 2 2 1 2 2 2 2 2 2 2 2 2	143.7	1424	1A29								1			-
2 1 8-512 23044 LTYDAKUH - 644 DBS NOHTHALLY 18 N. 3.004 3.007 SN. 776 776 Th 776 776 Th 776 176 Th .0056 .0056 III0056 .0056 III0056 .0056	THE STATE	1 55	•				RE	REALISTIC 8	PECTRUM	LOADING DIFTAILS	DETAILS		==	_
2 1 2 1000 1000 1000 1000 1000 1000 100	76/78	_	73/76		TOAD!	0	LEVEL		avo:	(Pounds	â		Z A Z	
2 1					M		""		FOR SP	FUR SPICTION NOS.	3,		TIME	_
LTYPARUH - 6M DMS MONTHALLY 18 M. 3.004 3.007 EN75 .74 Th .74 III0056 .0056 III0056 .0056 III0056 .225 2.23		~	3	-	_								(speconds)	
LTYTAKUH - 6A ORS - ROHTKALLY 18 N. 3.004 3.007 SN75 .74 Th .74 .74 III0056 .0056 III0056 .0056 III225 2.23	30,250		+					GOL	900	603	100	605		
#1088	ALLY AMERIED	T Can	•	_	1		-3.6						.3	
#1088 — MOHEMALLY 18 — IN. 3.004 3.007 — IN. 75 .74 — 17 .74 — 1110056 .0056 — I. R	8		4		2		-3.2						.2	
IN							-2.8	-1600	1600	1550	7600	-1600	.1	
111. 2 2.25 2.23	0;8		•	_	7		4.5-	-1500	-1475	1450	1400	2400	.3	
. IN	ğ	3.006	3.017		- 2		-2.0	-1200	-1150	0511	1150	1150	نه.	
. Th	_				9		-1.6	-1000	-950	-950	-300	-850	1.	
.74 .74 .76 .0056 .0056 R R 2.25 2.23	.75	F.	.75		7		1.2	-750	-750	00! -	-700	- 6 50	.3	
.0056 .0056 L R 2.25 2.23		Ę.	72.		8		0.1	-650	059-	053-	-575	-575	.2	
2.25 2.23	3500.	2	c\$00°	- -	6		9.0-	-500	-500	005-	7100	450	:	
2.25 2.23	.3	æ	H		10	 	.O	052*	05₹	-500	-250	-300	.3	
	2.25	2.23	2.36		=	_	٥	0	0	o	u	c	.2	
					12		1.0	650	650	650	600	575	.1	_
FAILURE OCCURATED DURING					13		5.56	1600	0091	3,600	1500	1500	.3	
MIGSION TYPE NO. 4	-3		-7		14		3.0	0061	1875	1900	1675	1700	.2	
					15		0.7	0592	0598	0092	2300	2300	١, ١,	
196 5	184	142	142		16		2.0	3250	3250	3250	2850	2950	.3	
(TABLES 33 (D)					17		0.9	3850	3900	3900	3400	3400	2.	
95 9	21	3	75		18		7.0	4500	4500	4500	4000	η τ ν υ	.2	
					19		9.0	5150	5150	51.15	14650	4650	.3	
0.014 C.74 u"2" ii 13val dari	0.8*	0.6+	0.6+		50		0.6	2800	5750	5800	5200	5200	7.	
	Г				ส		10.0	0049	0	0079	5750	2700	7.	_
4450 5850	51.75	1950	4950		g	ල	0	0	0	0	0	0	2.0	
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NOTES: (3) PAILURE OCCURRED DURING THE FIRST APPLIC	CLARRED DUR	100 70	FIRST APPLICA	ATTON OF THE	THIS LOAD.									
		-			_	<u> </u> 								-
ALI UNDI SIBLE CO	LEVEL MAN	ADDED F	LOAD LEVEL WAN ADDED TOR TESTING CON	WYDNIENCE CHIX.	, i									
TAT	ATT-LOTTA	777			_	_								
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												A Devision A	LOUNDE OF LOCKED ARCA	I AMERAPI	Lucrite ev-ucutura Cubrant A Divinde of Locinto Aberat Comporation		PAGE	TOTAL TOTAL
					PZASE II	BICK -	THE TOTAL	DEL JOINTS COPPIGURATION	RATION A	DAG.	No. 7226	7226-1302IIA-11A	VIT.					
PECTION NO. 11A	19000	91000	60016	40016	31005	90016	91AG	91A02	91403	STACE	SOTO	91001	30016	91003	groot	91005		
3	11401	11408	11408 11413	11402	11109	31416	11406	11405	11406	11711		11403	TOVIT	11410	11412	21415		
TIN OF THE	μ.	- STATIC -TENSILE		- STATE	- STATE COMPAN	MOISE.			PART.	SUE-LAP	N BELOKET	PROTE				•	- •	
R.T. RANGE OF	73	73	2	2	75	22	70/76	Æ	75/76	Ę.	70/7	17/01	70/73	11/01	71/12	73/75		
Was, the biss																		
DALTEC TEST OF			•		•	•	2	0	1	æ	c	6	9	9	9	3		
ADECREOD WATE.					8.213	BOROK	°245°0											
SPLICE PLACE MATL.						TIL	No.	SELLY AND	LALED									
ADERSTYR.							HOAR -	EA 9601	90.0							•		
SPECTMEN DIMENSIONS																		
LENOTE - IN.							1	MONTHALIZ		- 18.0						1		
AK. KEPER - 18.	1.498	3.005	3.007	2.005	3.005	3.005	3.002	3.001	3.003	3.005	3.006	3.003	3.004	3.006	3.006	3.005		
OVERLAP LENGTH - IN.																		
LEFT SIDE	1.01	3.	2.0	8,	1.00	8.	8.	3.00	8.	8.	1.0	8.	8.	1.00	1.00	- 66•		
RIGHT SIDE	8.	2.0	8,	1.01		1.0	8.	8.	8.	8.	8.	1.00	8.	8.4	8.	1.01		
PONDLINE TRICK. IN.	0400	.0050	9.8 8.8	88	•	88 88	98	7400.	9900	.0055	.0052	.0050	0500.	6400	.0055	•0050		
PATILINE SIDE	13	11	2	13.E	î.	TAB	<u> </u>	25	7	н	Я	R	æ	1	8	1		
PATURE ANEA - IN.	1.51	2.9					2.9	2.97	2.97	2.97	2.98	3.003	2.57	3.01	2.98	2.97		_
ULTINATE LCAD																	-	
Pau POUNDS	5830	11600	11400	5300	7700	9600												
ULTDUATE SHEAR																		
STATES Fou - Pas	3900	3900	3800	2700	3600	3300											_	
STREES RATTO (A)									R - +.1	9			ж Т	-30.0t		•	-	
HAX. LOAD POUNDS					L		2650	3270	3270	3270	3880	71160	ł .	4510		0944		
MAX. SHEAR STRESS-PSI							8	1100	3300	1100	1100	1500	1500	-1500	1500	7500		
CYCLE NATE - CFH							3700	1700	1700	1800	1800	1500	1500	1500	1500	1500		
PATICUE LIFE				L	_													
CYCLES X10"3																		
JOINT STIFFIESS																		
(1 88/1 1/11 HIDEN)10 ⁻³	£	399	357	E)	320	212	<u> </u>	39	95	04	16	90₹	294.4	122.7	28.6	59		
NOTES:	* FAILLE	e occura	TA NI CI	CHERTEND.													<u> </u>	
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9		LINE TES	P DISCO	so parjume tese discompanded a	THE TO CYCL	CYCLES.												
	ON REE EO	SEE HOUS 2 TABLE B3 FACE 6.	Z 33 E	.9 H	_													
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					PRAKE 11 BOID	1 9	JODING.	COSTIGURATION	METOR B	- DMG. N	BO. 7226-	7226-13021118-1A	1				ļ-	
	Г	Г	T	4	3	i a	\vdash	31000	11004	10011	ncos	11003	1100	33005	11006		†	
PECDER NO. 178	Т	Т	Т	1	7		Т	t-	6141	1462	1405	7041	TW	1413	3.005		†	
THO. SO. 7226-1302178.	1001	887	207	8			3				12	7	3	DAE'A -	•	-		
THE OF THE	1	u		PACTIO.			1	1	1	G / 83	01/19	27/22	68/73	27/13	11		-	
A.T. RANGE OF	Ž.	7.	10/11	12/92	78/75	e1/69	11/12	2	2	2								
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ANO. VIDER - III.	3,000	3.008	-	3.00	_	4	_	8	3 5	300	25	1.53	1.53	1.53	<u> </u>			
OVERTAR LEGIES - DIA	1.50	1.53	1.50	35.7	7.7	7:48	1.22	*	2	223								
MEDITINE TRECK III.							ᆚ	1		ᆚ		Post.	1	1365	2005	_		
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FINESS RATIO (R)	-	_		# (F	₹Ļ.					47.5	000	7103		-1105	-1110		_	\bot
MAX. TOAD POUNDS			g Ç	8	3	3	ŝ				1	6	L	L	L			
MY. STEAR STREES-PSI			8	1,600	0047	8	837				3 8	3	٤	120	1200			
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PAPTICINE LITTE								_					١	Į.	-	-		_
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												A DIVISION		D AIRCRAP	A DIVISION OF LOCKINGED AIRCRAFT CORPORATION	ı	Mag 115:22
					PHASE	PHASE II BONDE	ED JOINTS		CONFIGURATION B	B - DMG.	₽	7226-13021IB-1B49A	13-1349A	_			
SPECIDEN NO. IIB	12001	12D02	12003	12401	12A02	12403	12A04	12A05	37001	31002	31003	31401	31402	31403	31404	31405	
DMG. NO. 7226-1302TIB	3061	1805	9087	1901	1303	1304	1806	1307	200	5046	7046	1016	2403	1018	908	808	
साम अर सम्	ļ	7.1.1.1			- TATTOU	3. A.	R DAGA			111	1		TTGUE-I	ATTOUR-NAP INNO	TO KATEGO	9	
2.0 2422 92	12	1/2	74	76	75/76		74/76	73	12	*	12	72/75	72/75	70/75		72/75	
SPEC, N.P. NIM	•			7	3	3	9	3				3	9	9		Щ	
DOMESTIC STREET OF	•		•	-	9	3	9	3	•	•		3	9	9	5	5	
Andreas Marra 141.							16 PTY	nonon of /#45°	0,4								
TATES MATERIAL		ATTRACT	200 ma	٢				1			- PITTA	TUNE GAS	AV A	02142		1	
			•	2			l	1		İ							
ADMINITE .	•						NO NO	0 108	ŝ								
SPECIAL DISCIPLINES									1	1	1					1	
LEICHS - TE.	V						TOOL -	MONTHALLY 18.0								1	
AND VIDTO - II.	3,006	3,002	2.994	2.995	3.006	3.007	2.999	2.995	3.007	3,008	3.001	3.008	3.006	3.008	3.010	3.00	
OTHER PROPER - IR.	1.56	1.54	1.55	1.56	1.55	1.52	1.52	1.55	1.09	1.09	1.10	1.10	1.09	1.07	1.09	1.10	
REDUCE THICK - IN.																	
	,0055	,0055	,0055	.დგი	,0055	.0055	.0055	.0055	6500.	.0059	6400.	.0050	.0055	.0059	.0055	.0050	
free 2	9500	9900	6500	6400	•0060	6500'		.0059	•0059	.0059	.0050	.0059	.0059	.0059	.0059	0500	
	,0055	,0055	,0055	,0050	6500.	.0059		.0055	0900°	6500.	0900.	.0059	.0059	0900		0900	
PATTING AND - 11.2	٧.	٧.	٧.	٧.	٧.	٧.	٧.	٧.	•	8 *	8.	3.31	3.28	3.82	3.28	3.30	
UTETALTE TOAD																	
Peu Poume	15200	14800	14700						17700	16500	16600						
DIFTHER SPEAK																	
Trees You - Pai	3200	3200	3300						2400	2000	2000						
STREET BACTO (B)					- or 0+= 1	or		•					R = +0.10	01		•	
MAX. TOAD POSTED				6070	6060	5940	5930	6030				4630	4590	4510	4590	0844	
MAX. STRAR STREET-PSI				1300	1300	1300	1300	1300				1400	1400	1400	1400	1400	
CHOIR DATE - CTM				1800	1550	1525	1775	1800		_		1800	1800	1750	1800	1775	
PARTOIR LITE																	
crc128 x 10 ⁻³				14	22	92	28	21		-		1440	3770	21140	98	939	
JOHN STITMES																	
(149/11/18 WIDTE)10 ⁻³	984	193	510						643	633	637						
MOTHER "A - Pathers occurred	Curred	a aluminus adbe	edbe ru	·puə.													
" a Batlage o	POTATO	a baron	adberen														
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Precieen No. IIIA- 11E2 11D4 11D5 11D3 11D Descrice No. IIIA- 11E2 11D4 11D5-1 1402-1 1402 Expe of Test - 1602 - 1602 1 1402-1	1103 1105 1402-1 1404-1 140 74 74 70 0 0 Ply 0/ £ 4506wr 1.000 1.001 1.000 1.01	111 1101 1001 1001 1001	- BONDED JOINTS			TOUR TOUR	XXEED-(EORGIA ere macen	LOCKHEED-GEORGIA COMPANY A DIVINDA OF LOCKHED ARCEAFT COMPONATION	BANCOTT NAME III BI BACE 1
111.2 111.2 111.4 14.1.1 14.03	02 - 1 1404 Company of the company o	1M1 1M01 68 69	П	ITS CONFIGURATION	<					:
A-IIIA 1401-1 1403-1 Applies 2	02-1 1404- Comp 74 0 0 y 0/2 45 06wr	68	ı	1101	12D2	1203	1204	1241	1281	
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1.000 1.008 1.000 1.008 1.73 .75 (Mile) 1.75 1.6 1.6 1.6 1.6 1.73 .746 1.6 1.6 1.73 .746	06WT 06WT 000 1.001			3	0	٥	0		0	
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1,000 1,008 1 1,000 1,008 1 1,73 .75 . (M11a) L L L L L L L L L L L L L L L L L L L				•	ļ	- EA9601	90.	1	4	
1,000 1,008 1 1,000 1,008 1 1,73 ,75 . 1,41a L L L L L L L L L L L L L L L L L L L							_			
1,000 1,008 1 1,73 1,75 1,4 1,4 1,4 1,4 1,4 1,4 1,4 1,4 1,4 1,4	1-1-1-1			•	•	- 18.0 In	In. Nos.		•	
	 	0.01	10.00	10.00	1.001	౼	I	10.00	10.00	
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. (M11a) L L IN. ² . 730 . 746 3890 3750 3	П	72.	72.	1. Tr	.76	.76	72.	72.	.75	
. L L L L L L L L L L L L L L L L L L L		.74		-75	7.	₽.	.75	.75	.75	
L L L L L L L L L L L L L L L L L L L	E A12)					(3	(SEE TABLE	A12)		
IN. 4.730 .746 .751				L	æ	æ	ж	æ	В	
3890 3750 3400	146 046.	1.40	7.40	7.40	1.741	07/€	•448	1.40	7.50	
3890 3750 3400	\dashv									
	3540 3360				3670	3860	3860			
Fau - Stress 5300 5000 4500 4800	0051 00				9000	5200	5200			
Stress Ratio (R)				10.01				0.1	-1.0	
Max. Load Pounds				-1184				9620	0009	
Max. Shear Stress		1100	980	-160	_	_	_	1300	800	
Cycle Rate - CPM	_	300	300	064		_	_	38	300	
Fatigue Life			-			_	 	_		
Cycles X 10-3		195.9	11.4	1090		_	_	9.5	75.6	
Joint Stiffness			-		_	ļ _	L	_		
(15./In. 14th) 10-3 338 348 340 -	325				359	335	323			
						İ H	L	_		
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COMPANY	ACRAPT COMPOSATION
KHEED-GEORGIA	HON OF LOCKHEED AIRCRA
LOCK	A BUTTOOL

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		:		PHAJE 1	PHAJE III - BONDE	۵	JOINTS CONFIGURATION B	KATION B								
Specimen No. 1113	á	1102	1103	141	1811	-									- 	
DAG #7226-130213	1,101,1	1	7		1403											
Type of Test		Secto		Patigue	•										1	
R. T. Range Or	73	73	14	75	15		_									
Spec. Tesp. Rise				2	8	H	L									
Adberend Material 1	ļ	Soron 16 Ply		54 3/ 0	•											
Adherend Material 2	ļ	-11	179		•											
Adhestve		KA9601	546.		1											
Specimen Dimensions							_	_								
Lenght - In.			18.0 I	. Nom.	1	-	-		L							
Width - In.	1.003	1.001	1.003 1.001 1.003	10.00	10.00											
Bondline Inick.) (SEE	TABLE AT	3)													
Failure Area - DM.	1.48	1.47	1.48	14.9	14.9											
Ultimate Lund																
Pau - Lbs.	0664	06115	9990											1		
Ultimate Shear							_									
Isa - neg	3400	3700	0001				-									
Stress Retion (R)				0.1	-1.0											
Max. Load - Lbs.				20860	11840											
Max. Shear - PSI.				1400	900										_	
Cycle Mate - CPM				420	190											
Fatigue Life														-		
Cycle X 10"3				143	200	Н										
Joint Stiffmess																
(185/DK/DK NIDER) 10-3	899	6\$9	612			_										
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							•					LOCKHEED-GEORGIA	D GEOR		COMPANY		2 9	HEFORT IN.	12	
											7	Willes of	OCHERD 4		BPORATION.		2044			
					MA	PRASE 1 - 12	PECHANICAL JOINTS		- CONFIGURATION	MTTON B	- DHG -	NO. 7226	7226-13021E-1A	¥						
1					1	+	404.11	111406	111406	111407	11140B	111400	01411		31411	ETTIT	Marr	21411	diarre	2417
SPECTORIK NO. TE.		100	CONT.			╁-	٠.	۱.	1	<u> </u>	_		1451	1856	191	494	1439	1A5B	7422	1838
DIG. D. 728-1881		2	4	†- 1						Н	- 5	-3	RLINE DATA	1	1		-			
20 20 20 20 20 20 20 20 20 20 20 20 20 2	ļ	NATE OF	TATIC TERMINE	5	1,	1	72/77	74/16	72/92	*		—		73/76	73	70/73	77	17	72	2
1 - 1 - 1 - 1 - 1 - 1 - 1 - 1 - 1 - 1 -		2		1			∤ ~	├	-	-	Н				1	1		1		
12 . TB A.B.						2	0	60	~	4	3	~	8	6	8	-	-	4	•	4
THE LEE I							10,10	0	\$547	4 TNO TT	TENTION SE	- Sec. 188	-	\parallel			 			
THE WILLIAM							1		13				-			-				
EPLICK PLATE MATL.						+	-			-	H		7		1	+	1	1		1
TALE MEDIAL	•				<u> </u>				4-	7	-			! 						•
JOTTE SEATAR	•			#			#	\parallel		- 11-0						 				f
12000 - 11.	•						#		\parallel	 } 	-	+	+			1		950	3	٤
MACHINETER WITHER - 11	,999	606	756	8861	1687	2001	88	1001	88	9864	+	887	+	┿	8	8	100	3	*	
	L	8	986	1.000	.899	1.005	1001	186.	7.00	88.	8	100:1	8	╅	8.7	8	8	1881	887	3
TO THE DIAME LITTER	Poo.	8	8	600	88.	1.005	986	866	1.000	886.	126.	1.56	88.	886	8	785	8867	100	88	8
	4-	3 70	ž	240	10	940.	7.40.	4	940	840	940	. 940	940	7.0	1.43	18	8801	1047	98	9
	١.,	3	8	8	600	ğ	100	8	980		980	8	1883	100	8	88	190	100	000	180
The second second	1		9		151	133	101	15.	361	191	129	351	721	128	E	BETT	BEL	121	121	227
TI. MENT TRICK . IN		1									0.126					╢	 			
101										+	9	0.188		#			†† 			
SETTLES BORON NET >	"	One h	Calco.	2000	07.63	9900	19/0	.0733	4170	0000	7690	.0729	427.01	rguor	9420	OZZO	9520	1920	.0733	2275
COTTON OF STATE FORD												1	+	+		1				
0000100	200	3330	3200								-	-	1	+	1		1			
	***										- RE +0	-01.0+								
PRESE PARTO (R.)	-			S. S.	0110	2600	80%	1300	2070	2500	1	3460	5500	onsi	0152	23.0	25.70	25.90	24.90	2570
THE TANK NOROS CENTRES	17.	12	1	0.12	20.02	20.9	23.0	19.0	29.0	Ш	_	20.0	30.0	22.0	31.0	30.0	34.0	34.0	34.0	34.0
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	1040	CYCLIC	CYCLIC 1. * * 1260 LBS 1 'A' 1 900 L	260 1.83	1 '4'	900 118	N TOUR	NOOT C		TOAD	CYCLIC	1 '8' -	340 138	1 '2'	360 138	1 '4' =	375 LBS	BLOCK	BLOCK
	ş	34.48	1545	1.88	0.401	1.18	Ç.	Q.		Q	2772	dAC.	SET		1.85	2401	SCT	MO.	. Oil
		565	#1.W	MAX	X L X	XYX	-	(1)2			cPS.	MIR.	XT	MIN.	MAX	HIN.	MAX	1	(n)2
	Ŀ	-	930	260	1080	ş	-			^	-	-1225	2	0061-	098	-1350	375	7	•
	,	-	9	260	0967	ş	-	_		2	_	-1090	CPA	21150	360	1230	375	,	7
		7	06.2-	360	940	8	•	77		•		-950	340	-3030	360	-1050	375		_
	•	7	-625	260	-720	905	8	6		•	1	-815	376	-865	360	-300	375	B	
	\$	1	420	260	009-	905	11	11		5	7	099-	340	720	. 091	-250	175	,,,	,,
	9	,	-415	260	Q97~	906	15	15		9	1	-545	OF:	-678	998	009-	375	15	18
	7	ň	611.	260	97-	Ş	13	3.0			ď	-430	270	0.7-	360	450	175	18	18
	•	og S	-260	360	8	ş	8	3		•) O	-340	340	-360	360	-375	375	₩	400
	6	2	-210	360	-240	8	×	35		6	5	-270	978	-290	360	-300	375	×	35
	10	5	-105	960	-120	8	92	16		10	5	-135	340	-145	360	-150	375	76	76
	11	,	0	360	0	900	233	234		11	,	0	340	٥	360	٥	375	233	33.
	12	CI	360	665	Ş	710	3802	3803		12	91	340	670	360	920	375	960	3602	\$00
	13	30	260	780	906	006	6500	9069		13	10	340	1020	360	1090	375	1125	6500	005
	14	30	260	09C1	300	1200		3600		14	ગ	340	1360	360	1440	375	1500	3600	3600
	1.5	10	260	1.500	300	1500		1800		15	3.0	440	1702	360	1800	175	2875	1000	208
	ž	10	360	1560	\$	1900	610	810		91	10	340	2040	360	2169	375	2750	010	010
	1,7	\$	550	1820	272	2100	2.57	237		17	5	340	2,980	360	2520	375	2625	237	257
	18	,	997	2080	330	2400	77	45		18	1	340	2720	360	2880	375	3000	53	53
	13	1	360	2340	300	2700	7	8							TOTAL	CYCLES/BLOCK	LOCK	17603	17605
	20	1	260	2600	300	3000	1	1											
				TYFAL	CYCLES/	1	17602	17606											
	(1) B	Block Number 2 was applied	er 2 un	applie	ir the rever	rever'se	order of	f Block	Aumber 1	# Musber	3 WAS A	repeat	of Mumbe	r 1, and	Musber	A VES A	repeat of	Thusber	2. eta.
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DEPANY	T COMPOSATION
INEED-GEORGIA CI	OF LOCKWEED AIRCRA
200	PYTOR

		-		PHASE 1		AMICAL J	OINTS -	- MECHANICAL JOINTS - CONFIGURATION E		- DMG - NO	NO. 7226-13021E-38	1021E-38	A 18						
SPECIMEN NO. IE	122201	122702	122003	122401	122402	122A03	122404	122A05	122406	122A07	12240B 1	122409 1	122A10 1	112001	112D02 1	112005		_	
DKG, NO. 1226-190218	1803	1907	3812	3801	3802	3804	3805	3806	3809	3810	3811	3813	3B14	1802	1305	1308			
TYPE OF TEST	ST	STATIC-TENSILE -	311			PATTICUE		BASELINE	E DATA		+		İ	TATE-	TIC-TEMBILE-	4 3			
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SPEC. TRUE, RISE											 		-		-	-			
DURING TEST OF	•	,	•	2	22	0	12	23	8	-	14	50	18	-		-	-		
STRAP MATERIAL	V			- 8-PLY	ORON GO	ORON CO WITH TH	TITANI	SMIHS MG				 	1		BOROR	00/4450 + 1	TWO FITANIUM	SHINES	
CPLICE PLATE NATERIAL	1			- 9-PLY	OHON OO	AT HETA	TITANI	SMIKS M					À	10.PLY	BOROK	00/±45P . 1	TWO PITANIUM		
STRAP MATERIAL					TITANIO	1 841-1M	-1V			 			H		H		_		
HOLDE SEALANT					A MTS					Ħ			 	╫		4	-		
SPEC. LEMOTH - IN.	ļ				П	0 8				 	\prod		H	╫	╫	1	-		
ORON STRAP WIDTH - IN	1.002	1.005	666.	1.004	1.003	1	1,002	1.003	1,005	1.005	1.005	666.	.995	666.	666.	666.	-		
TI. STWAP WIDTH - IN.	.205	666.	1.001	1,005	966.	1.000	966.	.995	1,301	666.	666.	1.001	3.000	-	+	1,300	_	-	
BRLICK PLATE WIDTH - IN	_	.997	P66.	1.004	666.	1.004	866.	.994	1.002	666.	966•	966*	1.00.1	1.001	000	.998			
ORON STRAP THICK - IN	346	.045	. 245	.045	.046	.045	.043	.045	.045	.045	.045	.045	. 545	.047	.047	.048	 		
MINERD SECT. THICK IS	880	.083	1661	986	980	.389	980*	680	ο6υ ·	.992	160.	160.	.091	960*	. 095	.094		_	
TI. STRAP THICK - 1%.	.137	.127	.128	.127	,126	.127	.126	.125	.228	127	.135	.127	,124	.127	-	.125		_	
SPLICE PLATE THICK, IN	155.	1394	. 395	190.	.097	260°	.097	.097	.099	.095	260.	960*	. 660.	.094	.094	\$60.			
PASTERNAR HOLS DIA. IN.	V							.188					+	1	+	A			
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TOTAL HETINATE													-		-		_		
CONTROL - CONTROL	30.50	2920	3090											2990	30.50	3040			
ETHESS NATIO (R)							R = +0.	01		H	+	+	A		-	-			
WX, LOAD POUNDS				2150	2140	1830	2092	1822	1760	1760	2210	1770	2220			_	_		
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TICLE BATE - CPH				1790	1700	1730	1600	1800	1600	1600	1700	1700	1680		-				
PASTGUE LAPE															<u> </u>				
CYCLES X 10-3				25	249	22	39	93	392	256	1:	10	37	H	-	_	_		
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2-c1(Hagir, H1/H:/587)	133	CPT	137											126	8.1	135	_		
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AYD PAILINE MODE	;	3	7	3	>			7	۸	>	70	7	, .	- -	*				
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W . Thatener head pull thru in boron laninate.	ad Pull4	chru in	boron le	al nate.		_ 													
" - Mantener head rull thru and net seetion is lure of boron le	ad Sull-	theu and	net see	tion is	lure of	boron 1	minate	astener	ho!e.										
U - Met section failure of spline plate at fastener hole.	failure	of splik	· plate	at fast	ener hol	:				r	-	-	-	-		-	-	<u> </u>	-
T . Net seation	fat lure	of boron	at fan	tener ha	5	-			-	 	-	+	-	-	-		-	-	-

Bereit Connection

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12 12 13/77 11/77 17/74 74 74/16 73/77 77/74	211405 22 211405 23 5411 COUPTI 72/76 COUPTI 72/76 12/76 7/450 TTAKI 1-100-1V 1	SHIPS - 101 STA 100.		211803 2409 73/74 13/74 12 12 2995 2995 2996 2996 2065					112404 1807 16.78 13 14.000 1.000 1.000 1.000 1.000 1.000 1.000 1.000 1.000 1.000 1.000 1.000	2/13 2/13 2/13 2/13 2/13 2/13 2/13 2/13
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				PRASE 1	- MECHANI	NICAL JO	CAL JOINTS CONFIGURATIONS E	TOTAL		DMG. NO.	7226-150	7226-13021K-11A & 13A	A 13A				1			T
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					PRASE 11	2	CHANTCAL JOINTS	•	CONFIGURATION E	ATTON E	- DMG -	NO. 7226-1302118-1A	1302118	4					
SPECIMEN NO. 178	111502	111004	111205	111201	111203	1111006	131401	111402	111463	111404	SOME	111406	111407	111406	111409	017111			
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JOYAN SEALAND						_	D-112-11												
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BORON STRAP VIDTR - IN	1.966	1.964	1.965	1.962	1.971	T_	2.001	1.999	1.9%	2,002	1.999	2.000	1.999	2,000	1.999	2.000			
TI. STRAP WIDTH - IN.	_	1,961	1,965	1.957	1.969	1.970	1.995	1.995	2.000	2,003	2.003	1.999	2.000	1.995	1.993	1.996		-	
SPLICE PLATE WIDTH IN.	1.970	1.965	1.965	1.964	1.9.1	1.970	2.001	2.003	1.996	1.996	2.001	2.001	2,002	2.002	2.003	2.003			
DONOR STRAP THICK - IN	_	.045	.043	.044	.044	.043	.043	.044	.044	.045	.045	.044	.044	.044	.043	.043			
MINNED SECT. THICK IN	_	060.	780.	990*	060.	900,	.084	980,	690.	060.	990.	060•	980.	.067	.087	990.			
TI. STAP THICK - IN	_	0,130	.129	.130	.129	.128	.130	.129	.129	.129	.128	.131	.129	.131	.129	.1%			ļ
PLUCE PLATE THICK - 11	V						. 0.125									4			
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THE SECTION OF THE	.137	.143	.130	.136	.144	781.	.137	.140	.144	.146	.143	.146	:43	.141	.141	.140			
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toko - Pomps	7,00	7500	7160	9340	7160	2,00											-		
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St St. 151	*	2	22	3	8	22	ደ	23	۶	22	R	22	S	22	ဋ	22			
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			,	E	PRASE 1 -	- PECRANT	CAL JOINTS		COMPLETENATION	N P - DMC.	Š	7226-130219-14	17-1A		•
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"T" PLANCE WIDTH - IN	1.001	1.005	1.003	1.002	1.00	1.002	1.305	1.00.1	1.004	1.002	1,503	1,002	1.003	1.002	
"F" STEM WIDTH - IN											 				
DORON STRAP TRICK - IN	.043	.043	.344	.043	.043	.043	.043	.044	.044	.043	.043	.043	.043	.044	
SHIPPED SECT. TRICK IN	•00•	.08,	.064	.084	.084	.084	.084	.084	.085	.005	.085	•084	•084	790*	
"T" FLANCE TRICK - IN	•					-0.127									
"T" STEN THICK - IN	200.	,092	.083	,083	.083	.083	.083	.093	.083	.083	.082	.082	.084	•082	
PASTENER HOLE DIA. IN						-0.198								A	
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STATIC AKIAL LOAD AT															
PATLURE - POUNDS	3780	4490	3800												
PATTE SIDE LOAD AT															
PATLURE - POUNDS	163	250	640												
STATES RATIO (R)								a 10							
MAXIMUM DYNAMIC AXIAL															
LOAD - POUNDS				2000	2740	2740	2740	2740	2780	2770	2770	2740	2740	2740	
DYNAMIC AXIAL NET															
SPCT. STUESS - EST.				*	40	40	40	Ų	9	Q.	9	0	9	9	
DYNAMIC SIDE LOAD	 - -														
MAXIMM - POURDS				105	105	105	265	105	265	265	105	265	265	105	
MININGS - POURDS			-	8	32	35	235	35	235	235	95	235	235	95	
CYCLE BATE - CFR				1400	1550	1550	1675	1550	1650	1675	1725	1675	1675	1675	,
ZATIGUE LIZE													-		
CYCLES X 10-5				18	355	8	19	9	17	25	180	18	17	253	
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LOCKHEED-GEORGIA CORPANY NYMM OF LOCKHEED ANGRAPT COSPONTION 7226-15021F-3A ě PHASE I - MECHANICAL JOINTS - CONFIGURATION P - DMG. 20115 1.00 997 180 200 .138 8 . 29. 230 2 ;4 2 zaeroin intercementa nerecha 411A05 411A04 1.004 T BOROF O C +45 + FOUR TY TABLUM SETHS 3407 170 100 .139 100 850 1675 7 2 8 # 2 -1.003 3406 8 +0.10 111 .139 100 4860 1675 520 7 4 * 411402 1,004 270 73/74 -1024 9.127-1997 0.168 .139 82 1675 8 -- ALERT HOW TO 75 J.F.S. . 520 4 2 - STR 40-112-112-3,005 411401 100 3401 10/11 .139 3 100 ş a 4860 ġ 520 7 1,004 411105 6525 750 170 100. .139 300 62 1,003 -16-PI 41170% 3405 .139 8275 177 4004 TATE 8 23 8275 411001 "T" PLANCE VIDTH - IN 1 1,003 **5K72** 27. a 139 8 S 2 "T" PLANCE TEICK - IN. MINERD SECT. THICK IN NORTH STRAF MUTTE . 11 ORDE STATE THICK IN. SECTION STREES - KST DMG. NO. 7226-13021F MATHEM DITAME AXIAL FOR TREOF TYRE THE STEEL WIDTH - 18. SPICION DIMENSIONS AT PAILTHE - LBS. STATIC SIDE LOAD AT PALLUNE - POUNDS MATCHEL . POUTDR ACTUAL .. POTEN Di. MIC SIDE LOAD. R. T. RAWER OF SPEC. TREE. BISE. STATIC AXIAL LOAD DITAMIC AXIAL NET CTC'S NATE - CPA STRESS PAPEO (R) TOTAL SEALAST INCHE - IL LOAD - POOTUBE CTC1ES & 10-5 STRAP HATTRIAL ZATIGUR LIFE PATIENT NOTE TER OF TEST "T" HATTERIAL inticipated wo.

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			ЭН	OF GROW	HONDED JOINT TESTS		- GRAPHITE EPOXY APHERENDS	AY APREE	o - sandi	- CONFIGURATION	TION A				
Jpecimen No.	1001	ارد ا	E 1,003	10V1	E1A02	E 1A03	K1A04	E1A05	ELAGE	EMOT	ELAOB	E1A00	E1A10		
DWOF7226-13021A-0	*	\$.	124	×	8	3		Ϋ́	8	104	11	134	¥		+
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Spec. Temp. Rise								_							
During Test	•	٠	•	8	-3	٥	-	- -	-	0	7		9		
Adherend Mat1.			Crap	Graphite Epox	7.	Ply 00/	\$50								
Jplice Plate Mati.			71-64	4											
Adhest re			EA9601	3	1										
Specimen Dimensions						L									
Length	ı		Nomi	Nowthally 19 of In.	o In.		\prod			-					
•1dth	1001	1,004	1,010	1,003	700	1.005	3	700	1,303	100	210.1	3.016	200		
Overlap Length							_						+		
. left blue	72.	.73	.74	ղ	: <u>.</u>	.74	12.	17.	7.	7.	.75	.75	15.		
Right Side	.75	٠٦٤.	.74	.75		.75	7.	7.	72.	7.	.73	.72	1		
Bondline Thick. (Mile)	4.0	4.5	3.5	3.0	0.4	3.0	9	5.0	L	0.3	0,5	27	2 2		
Failure Side		1	æ	×	×	-1	ж	E	æ	×	æ	1	=		
Fallure Aren -Di.	.143	.733	747.	. 742	.743	447.	.743	.743	.742		.739	.732	Shr.		
Vitiente Lond		-											-		
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Liress Ratio (H)			-			; =	1 3						1		
Max. Load Pounds		-		1480	1240	1490		1410	1040	1490	1030	330	Original		
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Cycle Sate - 31%				1900	1750	1700	6571	1300	1600	1700	1650	1900	1750		
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PAGE TABLE VB2

1.027 1600 672 1050 2 5 5 Fattgue 1,006 12A09 14.70 1550 450 2 좚 8 3650 00 87 Static E2A08 1,008 1040 1400 1425 543 336 O E A - GLASS RPOAT ACHERINDS - CONFIGURATION A E2A06 E2A07 9A 10A 1490 2002 1550 8 ₹. 53 Patigue 1040 8 1.007 1525 143 .145 ៊ូ さた 15 4.5 #2A11 1.007 1250 1400 1425 5.5 3.5 Ç, 22 Static 76 #2DC2 1.007 3360 1,500 745 211 7. 7. 3.5 900 891 1490 1 75 8 00/2 1/20 Patigue BONDED JOINT TRESTS MA SA 80. 10.0 1550 1400 17. € 4 0 E 326 7. S-Glass, Epoxy - 8 Ply 1.005 1670 1600 25 2 5 5 3.7 Nominally 18.0 In. Static EA9601-045 WE. 12001 900*1 3330 4500 .736 23 5.15 3.2 5 92 #2A02 1.005 1030 87. 230 1525 3.5 ٥ Fattene R2ACT 14 1.00 1470 1550 5 5 Bondline Thick. (Mils DMD. #7226-13021A-FG Specimen Dimensions Length Adherend Mati. Splice Plate Mati. Failure Area . IN. Lo./In.Width) 10" Max. Shear Stress R. T. Range Oy Spec. Resp. Rise Max. Load inunds Cycle Rate - CPM Stress Patic (H) Cycles X 10-3 Joint Stiffness Overlap Length Pau - Pounds Ultimate Shear Fau - Stress During Test Ultimate Load Type of Test Hight Side Patlure 31de preises io. Laft Sids Adhostm Widen

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					FATLURE M	FATLURE MODES - BONDED	PED JOINTS	11			11		Ī		
ADMESTYR RVALUATION INSTE	ON TRISTS	MENO: - I REVIN	- A HOLLATION A -	- BACELDIK DATA	t nam t		_i_	PHASE	•	CONFIGURATION A - BASELINE TYPE AND PRESENTAGE OF	PERENTAGE OF	TAE DATA			
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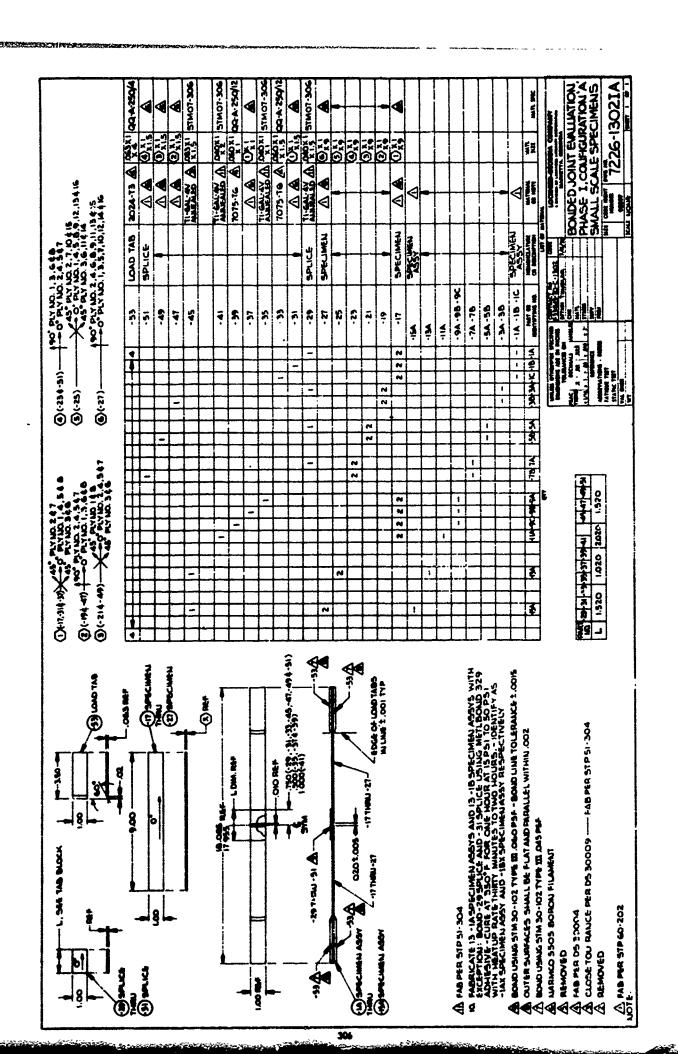
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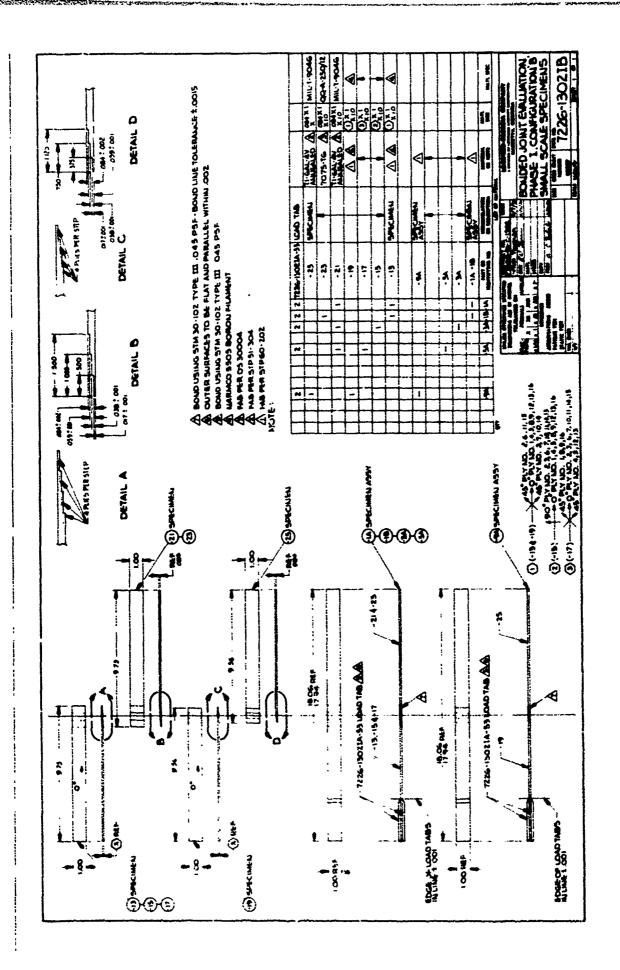
APPENDIX C

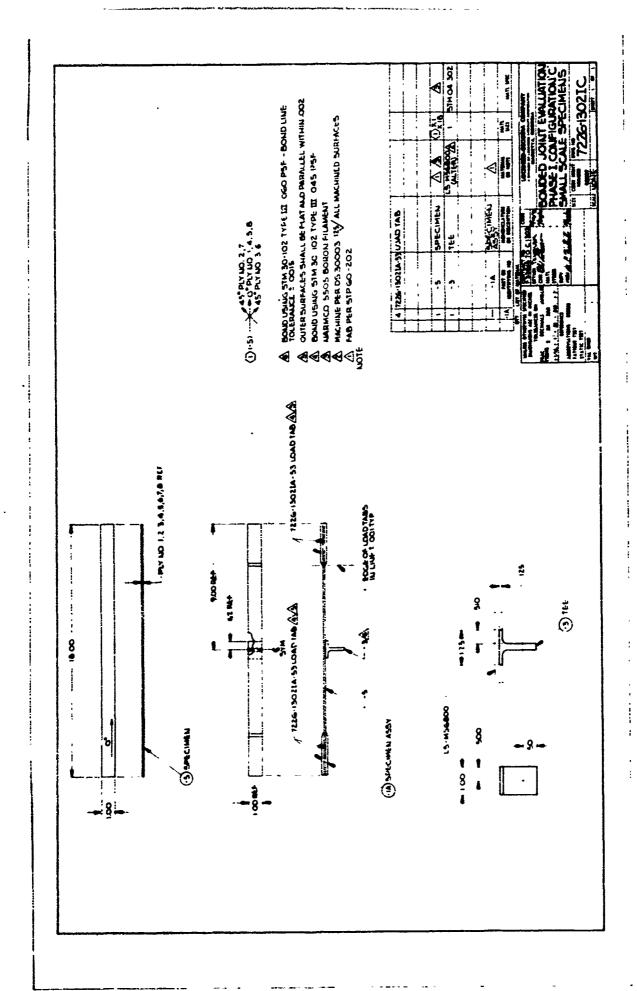
JOINT DESIGNS

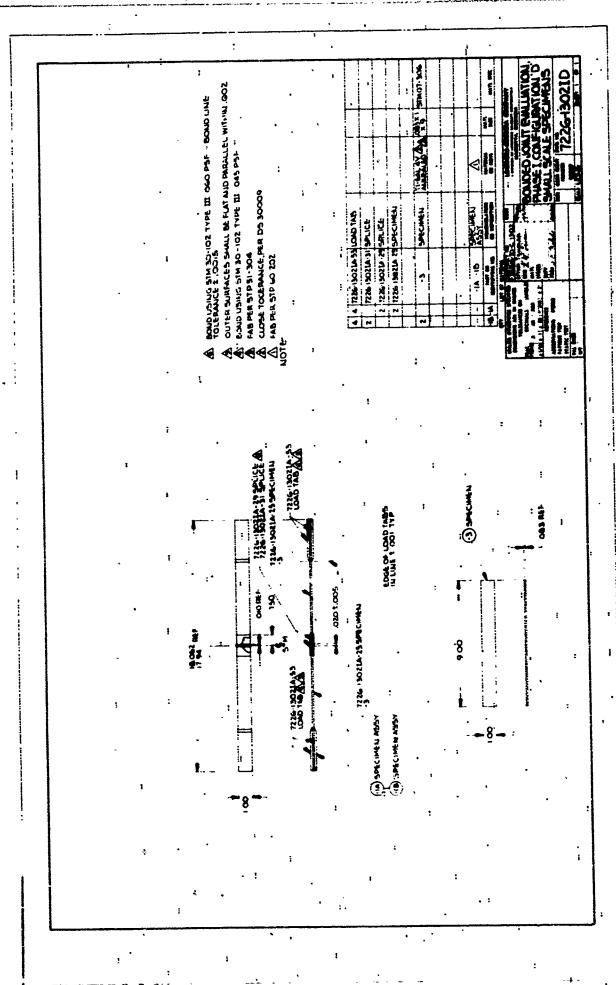
This section contains the detail design drawings for test specimen configurations under the evaluation program. Given below is a complete list of drawings and their usage.

Phase	Configuration	Status
ı	A, B, C, & D	Included
11	A & B	Provided as notes to Phase IA & B drawings
111	A & B	Provided as notes to Phase IA & B drawings
ı	E & F	Included
ii .	Ε	Provided as notes to Phase IE drawings

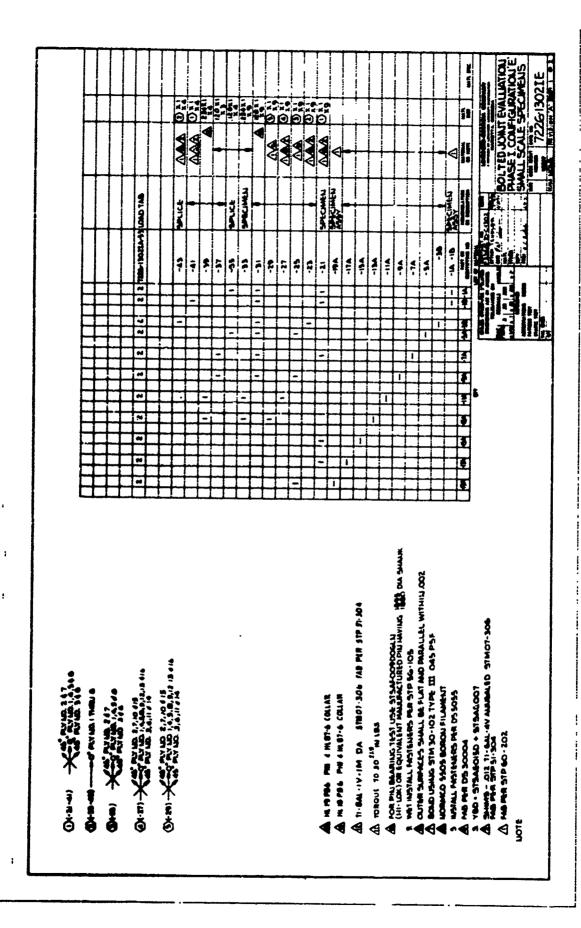






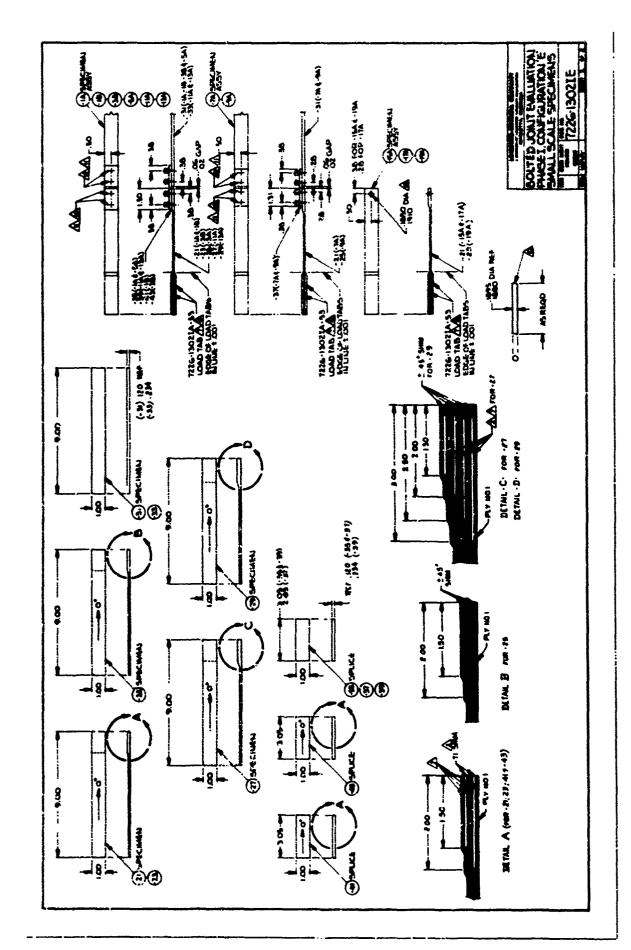


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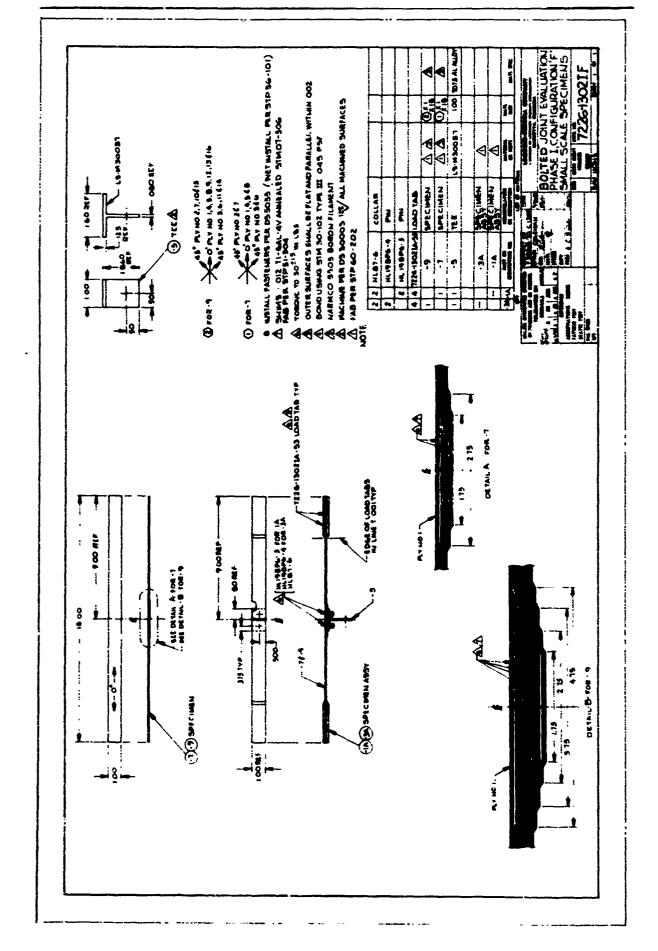
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